

FOREST

0-100

FIRE CONTROL HANDBOOK

PART III

REGION 5

1940



**U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE**

S. B. SHOW, Regional Forester

Part III

CONTROL AND DISPATCHING ACTION APPLICABLE TO LARGE FIRES

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FOREWORD

Through the systematic, repeated, analytical study of the individual elements that combine to make up fire suppression action, the officer who is planning such action will not only know how to evaluate the elements themselves, but will more or less automatically weigh and provide for handling each element in its proper relative position as actual fires occur. Fire strategy consists of correlating the scouting, initial action, subsequent line location, line construction, backfiring, mop-up and patrol, in their correct time sequences based on a careful rating of the probable behavior of fires under existing and predicted weather conditions and with effort devoted to each job comparable to its need.

Action to lay down on the ground the wherewithal to carry out the plans that are made within the time limits set is the direct responsibility of the dispatching agency.

HOW TO STUDY THE PROBLEMS

Work through each one in detail, being sure you understand all of the factors that were considered in arriving at the solution and how they were used. Try to work out other acceptable solutions which take account of the stated set of facts. Work out each problem to fix in your mind the points illustrated. Try to think of similar situations that might arise in country with which you are thoroughly familiar, and thereby translate the problems into your own experience to make them a part of your mental operating equipment.

Try also varying one factor in the problems, for example, wind velocity, wind direction, or initial rate of spread, and see what sort of a problem you get and how it would be solved.

HOW TO USE THE ANAGLYPH

1. Hold eye-piece so that red lens is in front of left eye, blue lens in front of right eye.
2. Using both eyes, hold the anaglyph in front of the eyes, changing the distance until correct focusing range is obtained. View anaglyph perpendicularly.
3. Study the anaglyph several minutes to acquaint yourself with all physical features. More intimate study can be made through use of a reading glass between the eye-piece and the anaglyph.
4. Read the problem through.
5. Study the problem with its relation to anaglyph.
6. Note the solution required.
7. From basic data given work through the solution of the problem.
8. Do not use eraser on anaglyph since it will eradicate the inked surface.
9. Study the aerial photograph on the reverse side of the anaglyph with a reading glass when necessary to observe details of cover, physical features, etc.

LEGEND

1. *Cover type*
 - a. *Boundary*—short dashed line — — — —
 - b. *Key to type*—non-capitalized letter ("a," etc.) description of which is given in write-up.
2. *Free-burning edge of fire*—continuous white line —————
Several problems will have two continuous white lines, one enclosing the other. When such lines are shown, they represent the position of the fire at two distinct periods that can be determined by reading the problem.
3. *Edge of fire which has been controlled*—continuous dark line —————
4. *Suggested control line location*—long dashed line —————
5. *Lines constructed and lost*—long dash, two short dashes, long dash, etc. ——— — — ———
6. *Roads*—Usually location of roads is described in write-up. However, in cases where there is no road and one is needed for the solution of problem, roads are shown by parallel short dashed lines = = =
7. *Trails*—Usually location of trails is described in write-up. However, in cases where there is no trail and one is needed for solution of problem, trails are shown by long dashed lines separated by an "x"
——— x ——— x ———
8. Major points used in discussion of problem—shown by capitalized letters (A, B, C, etc.).
9. *Starting point*—indicated by "x."
10. *Scale*—shown on each anaglyph.
11. *Position of north*—shown on each anaglyph.

CONTROL ACTION

Control action consists of the successive steps of scouting, appraising probable behavior of the fire, line location, selection of sector or sectors for first attack, decision on line construction methods, including use of machinery, appraisal of forces needed for line construction, decision on camp location, line holding, backfiring, mop-up and patrol.

It includes emergency action taken early in the game before full planning and mobilization is in progress. It includes prompt change of plans when major changes in weather occur without warning.

These major elements of the entire control process are considered one by one through use of fire problems. A group of problems also illustrates the more complex action required when many elements must be considered and solved on the same fire.

PROBABLE BEHAVIOR

Foreword

Appraising probable behavior of an individual fire is on firmer ground than it was three years ago. The additional available information is summarized in the following tables.

The application of these data in the complicated and difficult job of appraising probable behavior is illustrated in the problems which cover the more common situations met in practice.

TABLE 1
BASIC SPREAD RATES⁽¹⁾
CHAINS OF PERIMETER PER HOUR

Forest Groups	ZONE 1 (2)			ZONE 2 (2)	
	Average	5% Fastest	1% Fastest	Average	5% Fastest
North Coast (3).....	23.	88+	200+	10.	45+
East Side (4).....	19.	70+	160+	8.	45+
Southern Sierra (5).....	29.	130+	240+	9.	45+
All Northern California.....	20.	84+	200+	9.	36+
Southern California.....	42.	150+	275+	30.	130+

- (1) From work by C. A. Abell, P. D. Hanson, in the Regional Fire Replanning project.
- (2) Zones as defined in fire-replanning study and as shown on individual forest maps. Basic spread rates are not given for zones 3, 4, etc., since it is recognized rates of spread are low in these zones and large fires are relatively few in number.

- (3) Klamath, Trinity, Mendocino.
- (4) Shasta, Modoc, Lassen, Plumas, Tahoe.
- (5) Eldorado, Stanislaus, Sierra, Sequoia.
- (6) Los Padres, Angeles, San Bernardino, Cleveland.

Relations .

1. The 5% of total spreading fires in Zone 1 which makes fastest runs, make perimeter 4 - 6 times faster than average for region and Zone.
2. The 1% of fastest spreading fires in Zone 1 make perimeter from 7 - 10 times faster than average.
3. Zone 2 average rates are from 35 - 45% of the average for Zone 1 in same regions in Northern California and are 70% in Southern California.
4. Rates of spread shown in "average" columns above are rates which only one fire in four (25%) may be expected to exceed.

TABLE 2

EFFECT OF WIND VELOCITY ON RATE OF SPREAD (PERIMETER)¹

Assuming all factors identical *except* wind

<i>Wind velocity</i>	<i>Ratio (of wind to wind velocity shown)</i>
	9 ft. height— Level slope
0	1.0 (unity)
2	1.4
4	1.6
6	2.0
8	2.3
10	2.7
12	3.2
14	3.7
16	4.3
18	5.2
20	6.3
22	7.4
24	8.5
26	10.0

Illustration of use of above table

If a fire in a given type, fuel moisture and topographic conditions spreads at the rate of 10 chains in 1 hour with no wind, then from above table the spread under the same type, fuel moisture, and topographic conditions, but with a 20-mile wind, will give 6.3×10 or 63 chains per hour.

¹Based on work of California Forest and Range Experiment Station.

Chart A

SLOPE GUIDE

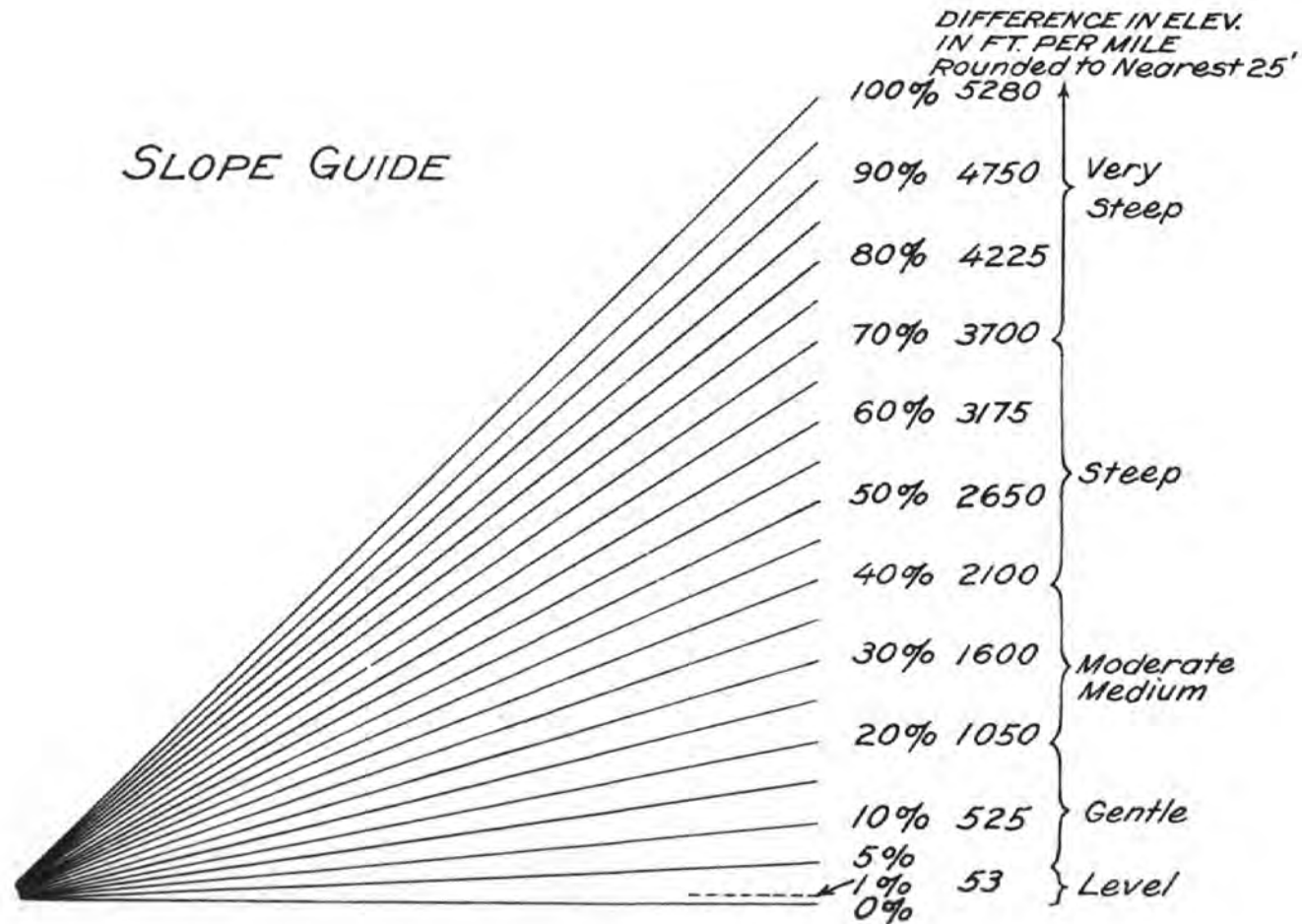


TABLE 3
RELATION OF RELATIVE HUMIDITY TO FUEL MOISTURE⁽¹⁾

<i>Relative Humidity</i>	<i>Per Cent</i>	<i>Approximate Corresponding Fuel Moisture Per Cent</i>
Very High	over 80	15.5 - 20
High	61 - 80	12.5
Moderate	41 - 60	8.5
Low	21 - 40	5.5
Very Low	20 or less	4.5 or less
Acutely Low	10 or less	2.5 or less

⁽¹⁾Approximate only since fuel moisture depends on duration of relative humidity rather than on the humidity at any given time.

TABLE 4
BEAUFORT SCALE FOR WIND VELOCITY

<i>Description</i>	<i>Wind Velocity Miles per Hour</i>
Calm	Less than 1
Very light	1 - 3
Light	4 - 7
Gentle	8 - 12
Moderate	13 - 18
Fresh	19 - 24
Strong	25 - 38
Gale	39 - 54
Whole gale	55 - 75
Hurricane	Over 75

TABLE 5
CHANGES IN RATE OF SPREAD

1. From slash cutovers to virgin timber.....	4 : 1
2. From steep (40-70%) to moderate (20%-40%) slopes.....	2 : 1
3. From steep (40-70%) to gentle (10-20%) slopes.....	4 : 1
4. From steep (40-70%) to steep (40-70%) down.....	16 : 1
5. From bronco grass to cutover ponderosa pine.....	2 : 1
6. From Inflammability Zone 1 to Zone 2.....	2 : 1
7. From Inflammability Zone 2 to Zone 3.....	1½ : 1
8. From normal daytime up canyon wind to night down canyon wind	16 : 1
9. From gentle up (10-20%) to gentle down slopes.....	3 : 1

**STANDARD OUTLINE FOR DESCRIPTION OF CONDITIONS
IN PROBLEMS**

1. Region and Inflammability Zone.
2. Time of year.
3. Time of day when planning begins.
4. Size of fire when planning begins.
5. Perimeter of fire when planning begins.
6. History to date.
7. Current weather.
Predicted weather.
8. Elevation.
9. Topography.
10. Rate of spread types.
11. Resistance to line construction types
Mop-up types.
12. Barriers.
13. Water available.
14. Manpower available.
15. Equipment available.
16. Roads and trails available.
17. Values.

PROBABLE BEHAVIOR

CALCULATING FUTURE FIRE POSITION ON BASIS OF FIRE'S PAST HISTORY WHEN ALL CONDITIONS REMAIN CONSTANT

Problem 1

USE FIGURE 1

Conditions

Region: East side, Zone 1.

Time of year: Mid-August.

Time of day when planning begins: 1:30 P.M.

Size of fire when planning begins: 90 ac., 90 ch. long.

Perimeter: 200 ch.

History to date: Start 11:15 A.M.; first attack 4 men 11:30 A.M.
20 chains rear of fire controlled at 1:30 P.M.

Current weather: SW. wind, 18 mi.; relative humidity, 10%; fuel moisture, 3%.

Predicted weather: Continuation of current conditions for 7 hours.

Elevation: 3,800' to 4,200'.

Topography: Level to 20% slopes.

Rate of spread types: Cutover ponderosa pine; bronco grass, sage.

Resistance to line construction and mop-up types: Ground fuels light; numerous snags in cutovers; numerous stumps and down logs.

Barriers: None.

Values: Uniform

Solutions Required

1. Size of fire, perimeter of fire at 6:00 P.M. when full attack is organized and on the line.
2. Hourly rate of perimeter increase after 6:00 P.M.
 - a. With front of fire free-burning.
 - b. With front of fire stopped.

Acceptable Solution

1. Fire has burned 90 ac. and is 90 ch. long in $2\frac{1}{4}$ hours. Fire is thus 90×10 ch. Perimeter is $90 + 90 + 10 + 10 = 200$ ch.
2. Four and one-half ($4\frac{1}{2}$) hours remain before full attack is ready; that is, 2 times the period from 11:15 to 1:30 P.M.
3. Weather conditions remain constant.
4. Topography uniform and will not affect fire behavior.
5. No barriers to affect behavior.
6. Rate of spread types uniform.
7. From 11:15 A.M. to 1:30 P.M. ($2\frac{1}{4}$ hrs.) fire has made perimeter of 200 ch. at rate of 90 ch. per hour. From 1:30 to 6:00 P.M. additional perimeter will be 400 ch. Therefore, at 6:00 P.M. perimeter

of fire will be 600 ch. and area will be 1,300 ac. (area from Area-Perimeter Table, Page 180, Fire Control Handbook).

8. The direction of main axis, and proportionate length of sides and front will not change materially.
9. Fire from 6:00 P.M., weather conditions remaining constant, will make about 90 ch. new perimeter per hour ($600 \div 6\frac{3}{4}$) until head is stopped, since fire will continue to spread at 6:00 P.M. rate. It will make only 6 ch. per hour new perimeter ($40 \div 6\frac{3}{4}$) after head is stopped. This is due to perimeter increase along uncontrolled flanks.

PROBABLE BEHAVIOR

EFFECT OF TIME OF DAY ON CALCULATION OF PROBABILITY

Problem 2

Conditions

Same as for Problem 1, except

Time of day when planning begins: 3:45 P.M.

History to date: Start at 1:30 P.M.

Solution Required

Perimeter of fire at 6:00 P.M. when full attack is organized and on the lines.

Acceptable Solution

1. Fire has been free burning for $2\frac{1}{4}$ hours.
2. Two and $\frac{1}{4}$ hours remain before 6:00 P.M.
3. Additional spread will be approximately equal to that already (200 ch.).
4. Total perimeter at 6:00 P.M. thus approximately 400 ch. (200 ch. + 200 ch.).

(See Appendix 17, General Section, Fire Control Handbook for all Area-Perimeter Relations.)

PROBABLE BEHAVIOR

EFFECT OF CHANGE IN WEATHER CONDITIONS ON CALCULATION OF PROBABILITY

Problem 3

Conditions

Same as for Problem 1, except

Size of fire when planning begins: 35-40 ac.

Perimeter of fire when planning begins: 100 ch.

Current weather: SW. wind, 10 mi. per hour.

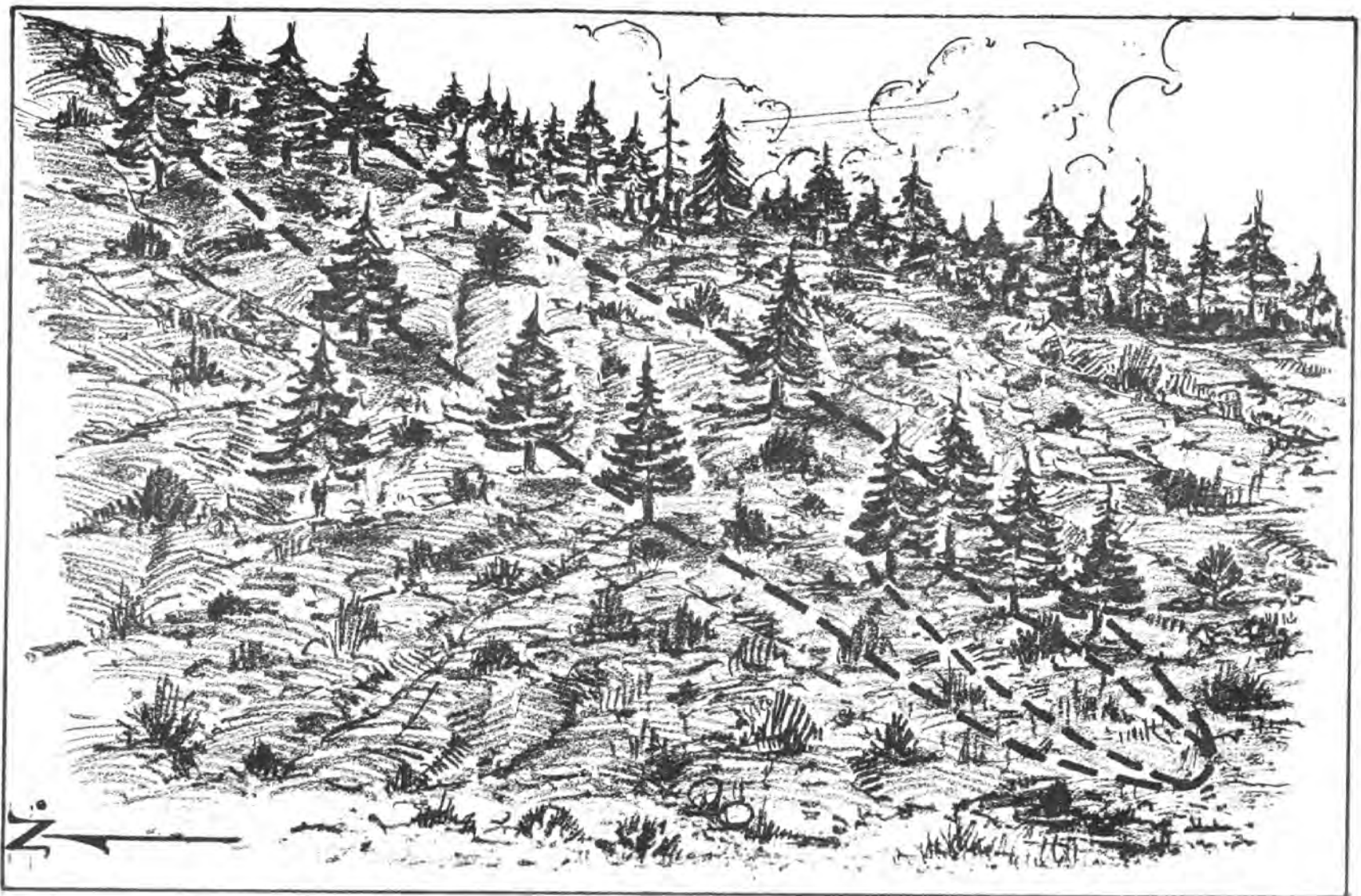


Fig. 1

Scale 2' = 1 mi.

Solution Required

Same as for Problem 1.

Acceptable Solution

1. Area-perimeter relation is that for medium-spread fires (middle column, Appendix 17, Area-Perimeter Table, Fire Control Handbook).
2. Dimensions of fire at 1:30 P.M. = 40 ch. $\times$ 10 ch., period of spread = $2\frac{1}{4}$ hours or $\frac{1}{3}$ of total spread period of $6\frac{3}{4}$ hours.
3. Dimensions of fire 120 $\times$ 30 ch. at 6:00 P.M.
4. Perimeter at 6:00 P.M. 300 ch.
5. Or:
Remaining free-burning time divided by free-burning time to date, times present perimeter, plus present perimeter = perimeter at end of remaining free-burning time. Or $(4\frac{1}{2} \div 2\frac{1}{4}) \times 100 + 100 = 300$ ch.

PROBABLE BEHAVIOR

EFFECT OF CHANGE IN WIND VELOCITY ON CALCULATION OF PROBABILITIES

Problem 4

Conditions

Same as for Problem 1, except

Predicted weather: Wind drops to 4 mi. per hour at about 6:00 P.M.

Solution Required

Rate of fire perimeter increase after change in wind velocity.

Acceptable Solution

1. Total perimeter at 6:00 P.M. same as for Problem 1.
2. Rate of hourly perimeter increase with front free-burning fire will drop from 90 ch. to about 27 ch. due to reduction in wind velocity. See Table 2, Effect of Wind Velocity on Rate of Spread. 5.2 for 18 mi. wind, 1.6 for 4 mi. wind.
 $1.6 \div 5.2 = .3$ or in round figures a 4 mi. wind will have only .3 as much effect on rate of spread as an 18 mi. wind. Rate of spread of $90 \times .3$ or 27 ch. per hour would be perimeter increase.

PROBABLE BEHAVIOR

EFFECT OF CHANGE IN TYPE ON CALCULATION OF PROBABILITIES

Problem 5

Conditions

Same as for Problem 1, except

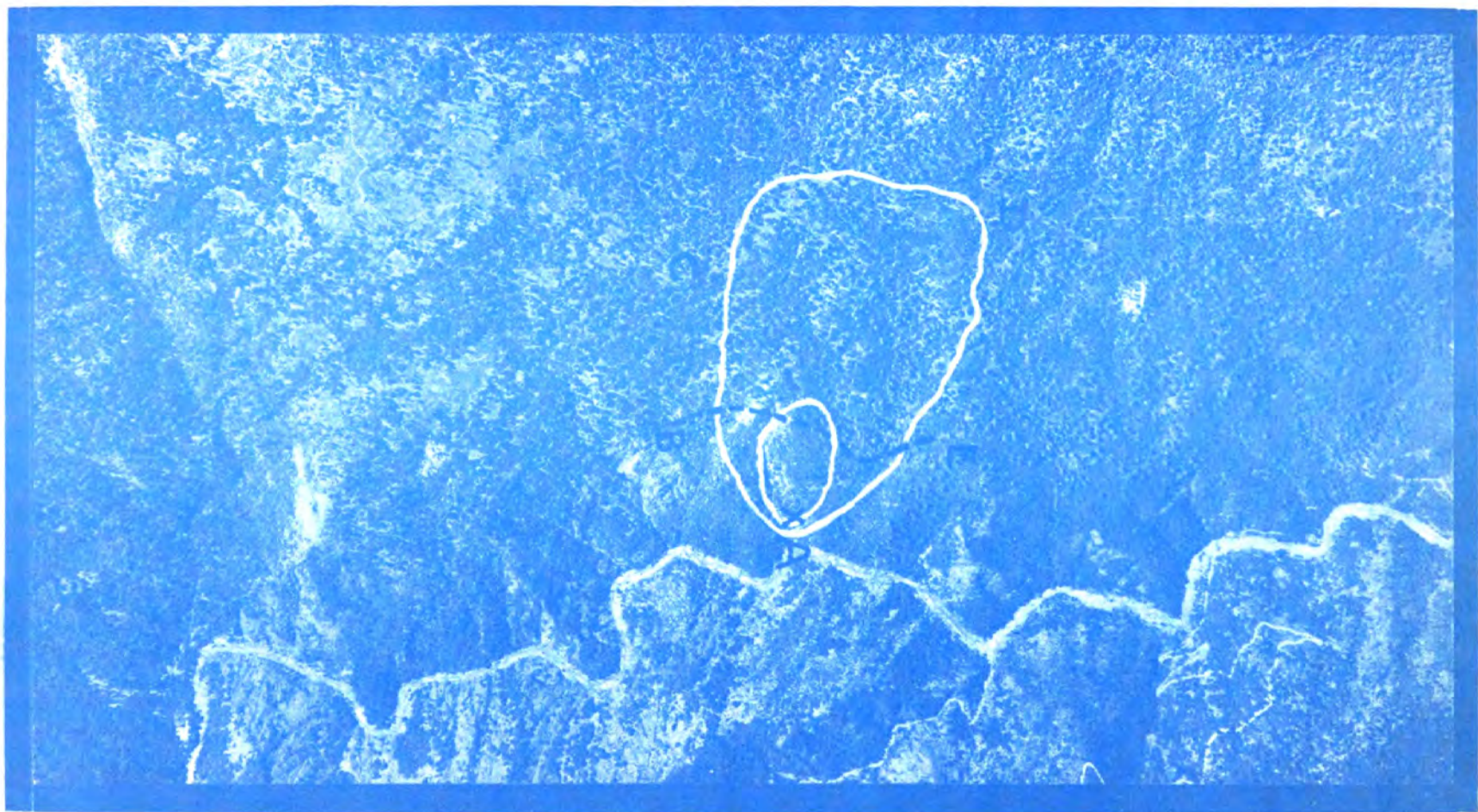
Rate of spread types: Cutover ponderosa pine type at start and for 130 ch. linear distance along main axis of spread. From that point in virgin ponderosa pine ($\frac{1}{4}$ rate of cutover type).

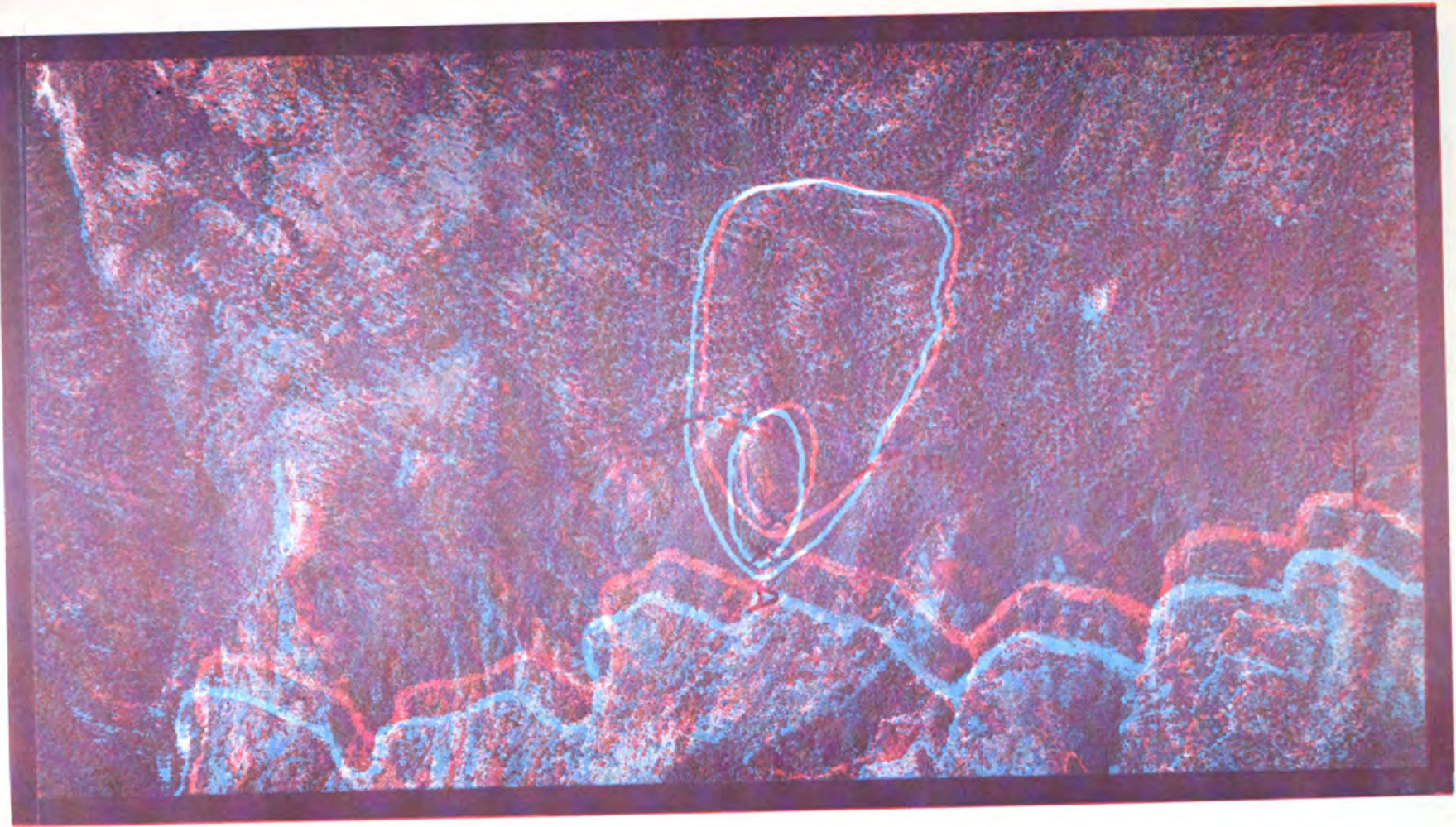
Solution Required

Same as for Problem 1.

Acceptable Solution

1. Fire will continue at 1:30 P.M. (original) rate of spread until reaching virgin timber.
2. This will be at 2:30 P.M. (Fire has spread 90 ch. forward in $2\frac{1}{4}$ hours or 40 ch. per hour. Thus 130 minus 90 = 40 ch. yet to go to timber. Time to spread 1 hour; 1:30 P.M. plus 1 hour = 2:30 P.M.)
3. Assume that hourly rate of linear advance along main axis will, in timber, be $\frac{1}{4}$ that in cutover, then rate will be $40/4 = 10$ ch. linear advance.
4. With free-burning period from 2:30 to 6:00 P.M. or $3\frac{1}{2}$ hours in virgin timber, perimeter in that type will be at 6:00 P.M. $10 \text{ ch.} \times 3\frac{1}{2} = 35 \times 2 + 20$ (width of front) = 90 ch.
5. Perimeter in cutover will be $130 + 130 + 10 = 270$ ch.
6. Total perimeter at 6:00 P.M., $90 + 270 = 360$ ch.
7. Hourly rate of perimeter increase from 6:00 P.M. on free-burning fire, $10 + 10 = 20$ ch. (the rate in virgin timber from 3 above).





PROBABLE BEHAVIOR

EFFECT OF CHANGE IN TYPE AND SLOPE ON CALCULATION OF PROBABILITIES

Problem 6

USE FIGURE 2

Conditions

Region: West side, Zone 1.

Time of year: August

Time of day when planning begins: 11:30 A.M.

Size when planning begins: 9 ac.

Perimeter when planning begins: 40 ch. (15 ch. long, 10 ch. wide).

History: Fire started 11:00 A.M.

Weather since start of fire: N. wind (up slope), 2 mi. per hour; relative humidity, 25%; fuel moisture, 5%. Weather conditions will continue without change until 7:00 P.M.

Elevation: River bottom 2,400', top ridge to south 3,700'.

Topography:

(a) Brush slope (where fire started) = 65% slope (up to line E-B).

(b) Between line E-B and ridge C-D = 20% slope.

(c) South of ridge C-D to bottom of draw = 25% slope.

Rate of spread types: Brush on 65% slope, timber on 20% up slope and on 25% reverse slope.

Barriers: River north of fire will be effective since there are no serious interlocking points and run of fire is strongly up slope.

Solution Required

Determine location and area of fire when suppression forces arrive on fire ready for duty at 4:00 P.M. with full consideration to effect changes of slope and type have on rate of spread.

Acceptable Solution

1. *Effect of slope on rate of spread.*

Change from 65% to 20% slope will reduce rate of spread by about 50%. The hourly rate of perimeter increase on 65% slope was 80 ch. per hour. The rate on 20% up slope would be 40 ch. if type remained constant. On reverse slope rate of spread will be $\frac{1}{3}$ of rate for 20% up slope, with type constant.

2. *Effect of change of type on rate of spread.*

Regional average rate of spread for timber is $\frac{2}{3}$ that for brush.

3. *Combined effect on rate of spread of change in slope and type.*

a. On perimeter.

80 ch. per hour cut to 40 because of slope; reduced $\frac{1}{3}$ more in change from brush to timber, or 27 ch. per hour perimeter increase to top of ridge. On down slope, $\frac{1}{3}$ of 27 ch. or 9 ch. per hour perimeter increase.

b. On axis.

Similar ratio will exist so forward spread of 15 ch. in brush on 65% slope in $\frac{1}{2}$ hour will be reduced to $7\frac{1}{2}$ ch. because of slope and $\frac{1}{3}$ more because of change to timber type, or a rate of axis spread after 11:30 A.M. of 5 ch. per half hour. Fire would reach ridge which is 28 ch. away at that time in 2.8 hours or at 2:18 P.M. Reverse grade rate of spread = $\frac{1}{3}$ of up hill rate of 10 ch. per hour or $3\frac{1}{3}$ ch. per hour, so at 4:00 P.M. fire will have dropped over the ridge $1.7 \times 3\frac{1}{3} =$ about 6 ch.

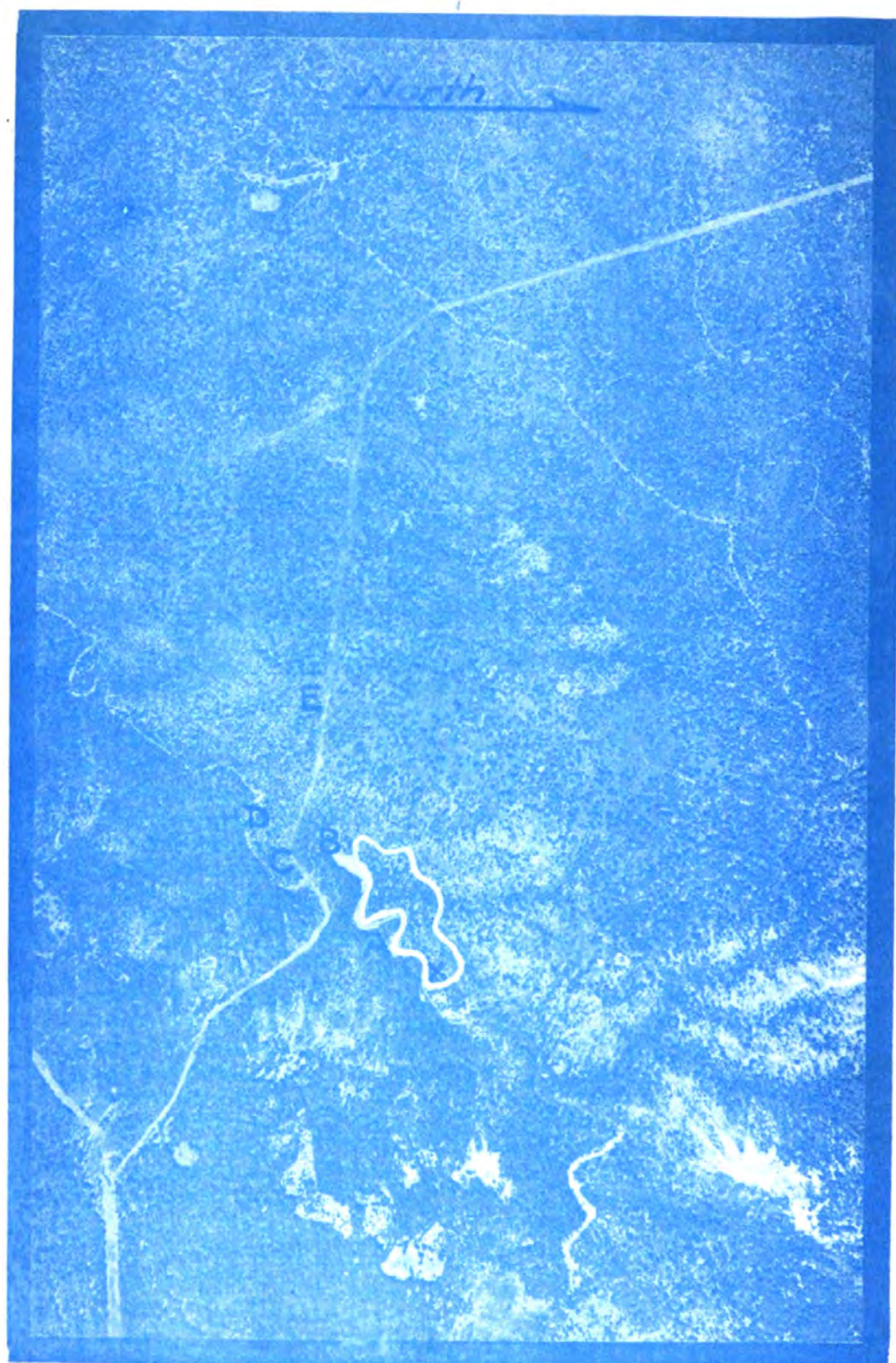
4. *Area.*

40 ch. perimeter at 11:30 A.M. — 9 ac.

27 ch. per hour from 11:30 A.M. to 2:18 P.M.; total 76 ch.

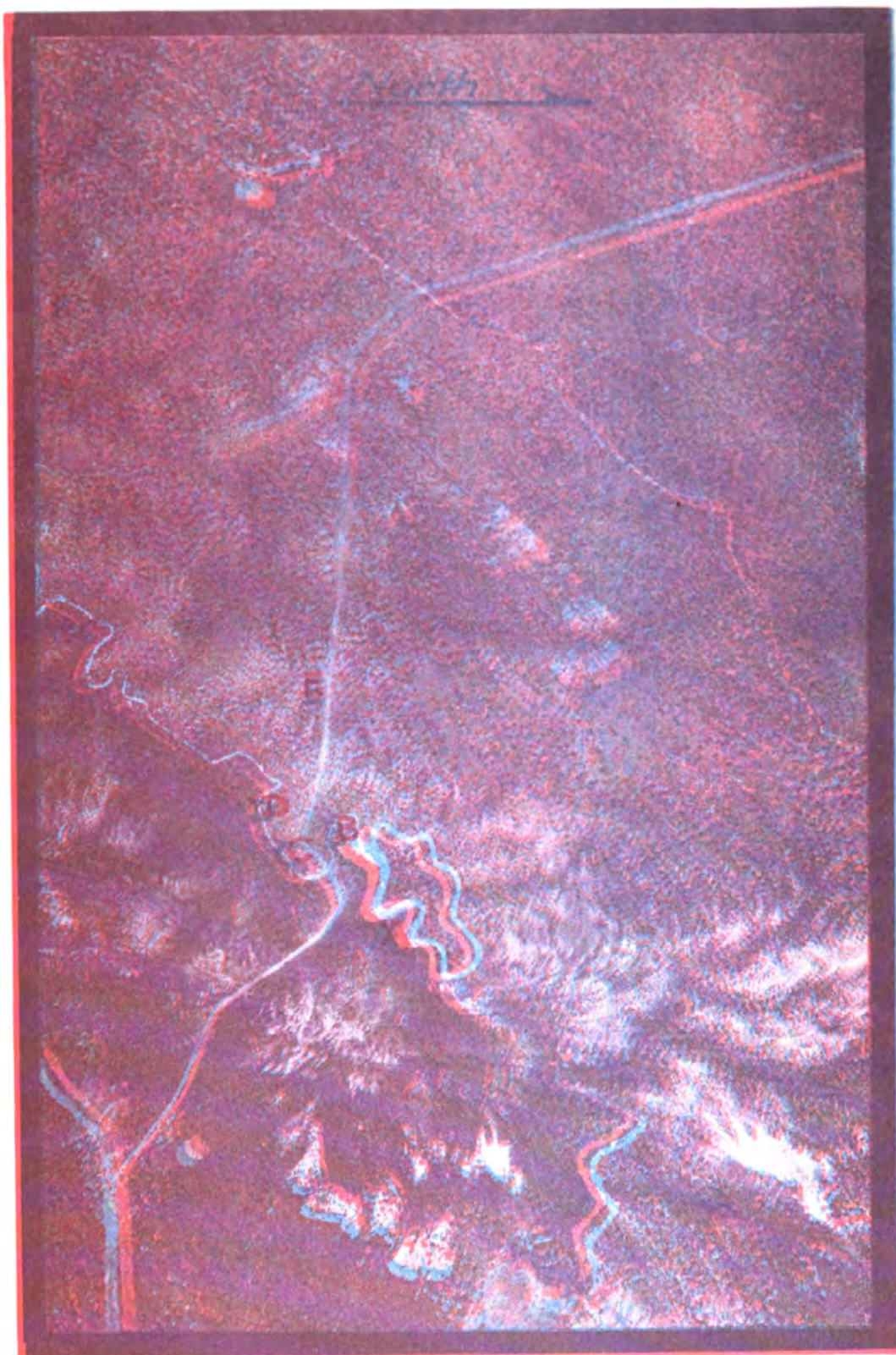
$3\frac{1}{3}$ ch. per hour from 2:18 P.M. to 4:00 P.M.; total about 6 ch.

Total ch. 122; area 109 ac. See larger area enclosed by solid white line for estimated location of fire at 4:00 P.M.



Scale 3" = 1 mi.

Fig. 3



Scale 3'' = 1 mi.

Fig. 3

PROBABLE BEHAVIOR

EFFECT OF CANYON WITH INTERLOCKING POINTS ON FIRE BEHAVIOR

Problem 7

USE FIGURE 3

Conditions

Region: West side Sierra, Zone 1.

Time of year: July.

Time of day when planning begins: 2:00 P.M.

Size when planning begins: 15 ac.

Perimeter when planning begins: 65 ch.

History: Fire started at 1:00 P. M.; suppression crew arrives on fire at 2:00 P.M. .

Weather: NE. wind (down canyon), 15 mi. per hour; relative humidity, 23%; fuel moisture, 5%. Weather to continue without change to 7:00 P.M.

Elevation: Creek 3,300', top ridge to NW. 4,900', top ridge to SE. 3,800' .

Topography: Steep slopes (40%) northwest of creek. Moderate slopes (30%) southeast of creek.

Barriers: Creek forms partial barrier, but due to interlocking points is not as effective as should be.

Values: Uniform.

Solution Required

Plan of attack with full consideration given to difficulties of behavior because of interlocking points in the canyon.

Acceptable Solution

Fire spreads south and west along creek and climbs the slope. Points of special danger A & B, C & D, because of likelihood of fire crossing on them from northwest to southeast side of creek. Efforts of initial attack crew should be directed toward manning creek at points A and B with men placed on east side of creek to pick up any spots that might blow across. Take similar action with respect to points C and D should a fire approach there. Plan to stop forward run of fire on west of creek along cleared transmission line C-E; then as forces arrive work west and north sides back to canyon near the starting point. Try utmost to prevent further spread along the creek to keep away from continuing danger of interlocking points.

PROBABLE BEHAVIOR
HOW TO COMPUTE PROBABLE FIRE BEHAVIOR

Problem 8

USE FIGURE 4

Conditions

Region: Southern California, Zone 1.

Time of year: August.

Time of day when planning begins: 2:30 P.M.

Size when planning begins: 18 ac.

Perimeter when planning begins: 50 ch. (20 ch. long, 4 ch. wide).

History: Fire started at 2:00 P.M.

Weather, current: SW. wind, 15 mi. per hour; relative humidity, 10% ; fuel moisture, 2.5%.

Elevation: 1,000' to 6,500'.

Topography: Moderate slopes with deep canyons. About 3 mi. from canyon to main ridge.

Rate of spread types: Mature, unburned chamise, manzanita, scrub oak, medium density and height.

Roads and trails: Highway runs along the lower edge of the fire with trail along main ridge above the fire (A-B).

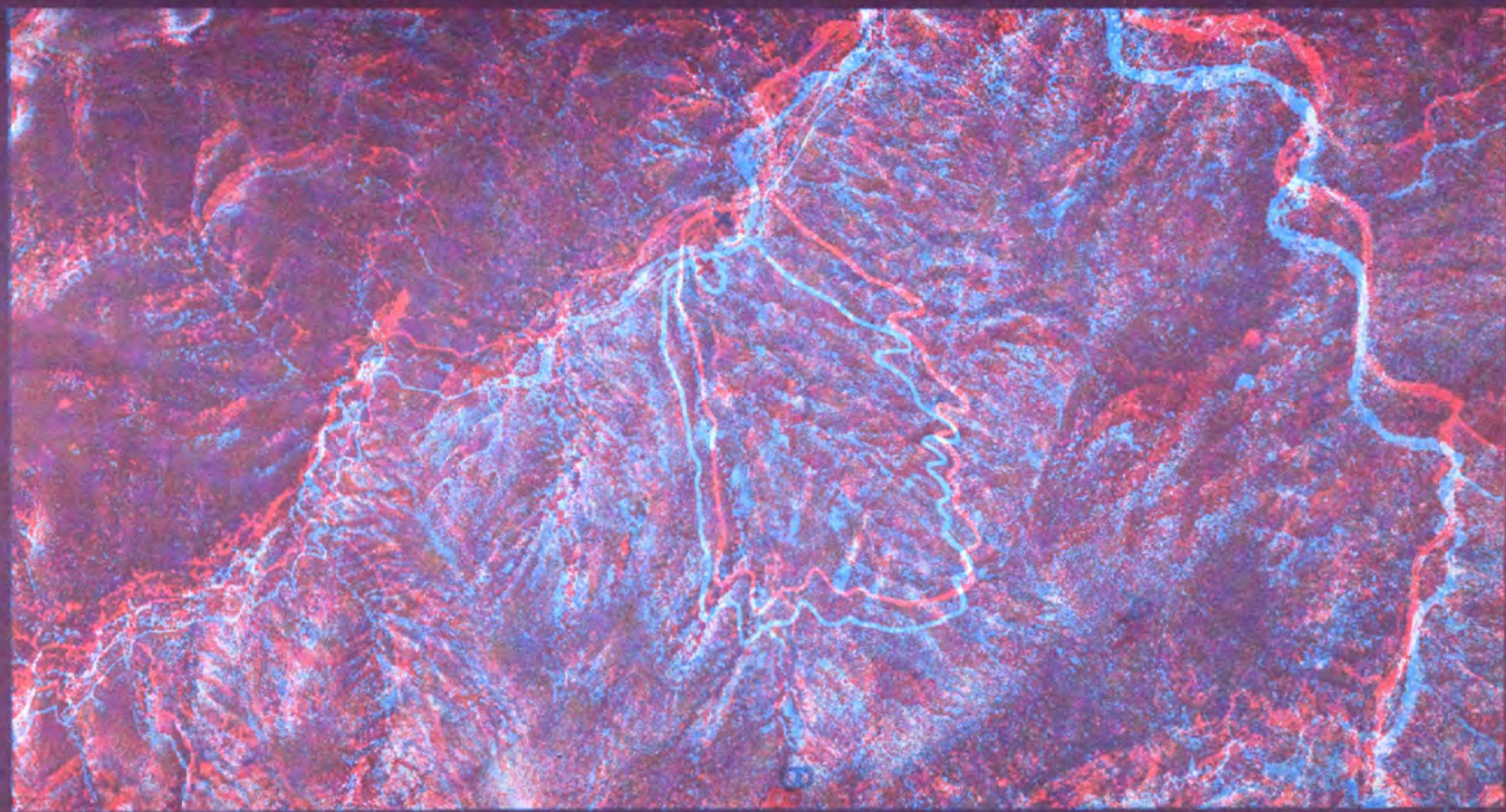
Values: Important watershed in which area burned should be held to lowest practicable point.

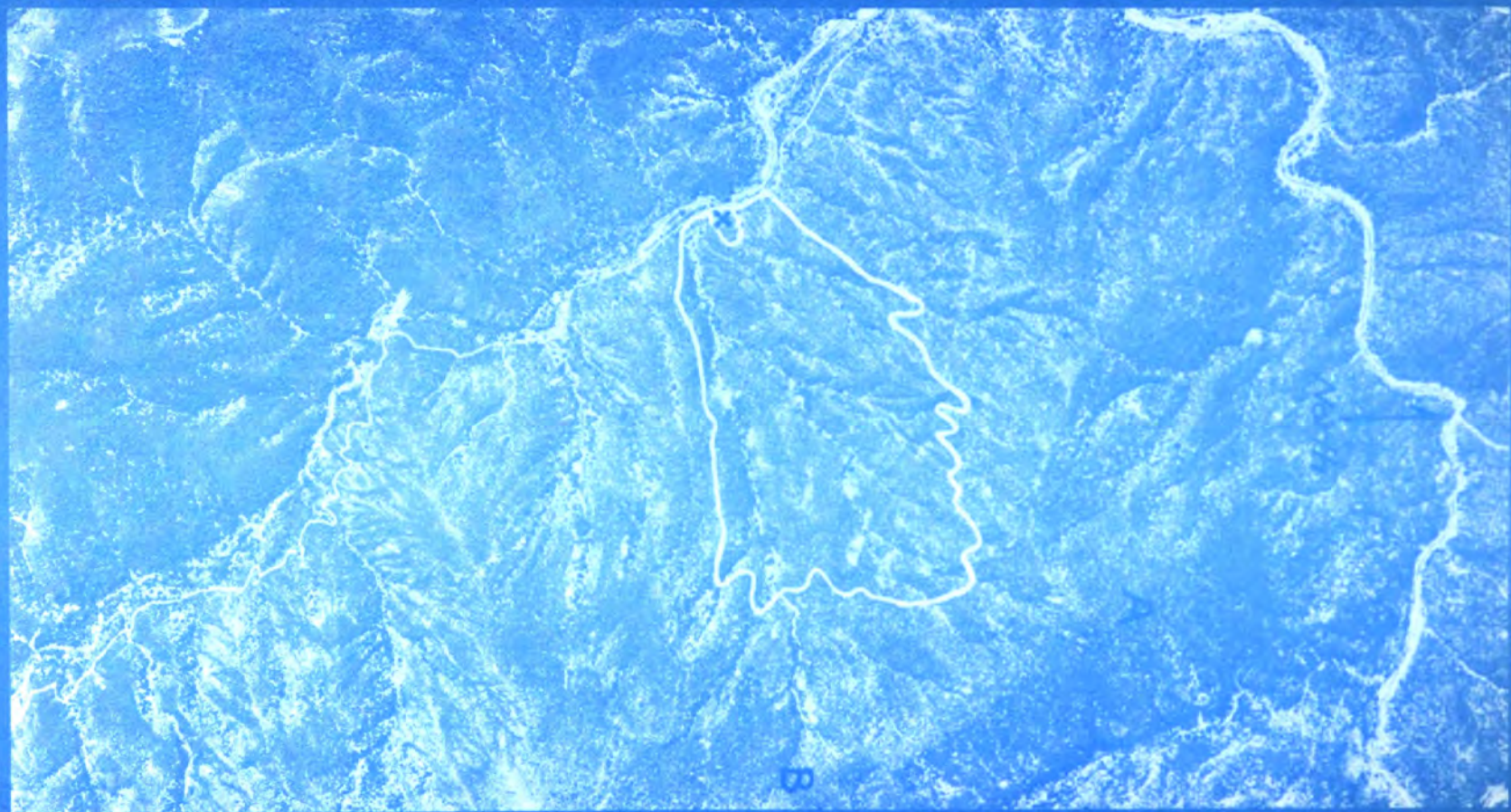
Solution Required

Perimeter of fire, probable location and size of fire area at 7:00 P.M. when full force is on the lines ready for attack.

Acceptable Solution

1. Fire burned at such a rate that at 7:00 P.M. it would have made a total perimeter of 500 ch. and covered approximately 1,000 ac.
2. This is figured at the rate of an increase in perimeter of 100 ch. per hour for 5 hours from 2:00 to 7:00 P.M. The total area is obtained from the fire area perimeter table.
3. Fire will not have reached main ridge by 7:00 P.M. since main axis should not normally exceed 200 ch. while the ridge was slightly over 240 ch. distant from the canyon bottom.





PROBABLE BEHAVIOR
HOW TO COMPUTE PROBABLE BEHAVIOR

Problem 9

Conditions

Same as for Problem 8, except

Size when planning begins: 10 ac.

Perimeter when planning begins: 71 ch. (26 ch. long by 9 ch. wide).

Solution Required

Same as for problem 8.

Acceptable Solution

1. Has burned 71 ch. perimeter in $\frac{1}{2}$ hour.
2. Has $4\frac{1}{2}$ hours to go. Will create about 640 additional ch. perimeter and be about 260 ch. long with a total perimeter of 710 ch. and an area of 1,000 ac. by 7:00 P.M.
3. This means fire will be slopping over trail on main ridge unless head effectively attacked on ridge before 7:00 P.M. It will reach trail A-B slightly before 7:00 P.M.

PROBABLE BEHAVIOR

HOW TO COMPUTE PROBABLE BEHAVIOR

Problem 10

USE FIGURE 5

Conditions

Region: Southern California, Zone 1.

Time of year: September.

Time of day when planning begins: 3:00 P.M.

Size when planning begins: 170 ac.

Perimeter when planning begins: 200 ch. (85 ch. $\times$ 25 ch.).

History: Fire started 10:00 A.M. The initial attack crew of 10 men had been unable to hold line.

Weather: Light SW. wind; relative humidity, 14%; fuel moisture, 4%. Conditions were due to get better at night with humidity up to 20% and fuel moisture to 4.5%; wind down.

Elevation: Range from 2,500' to 3,500'.

Topography: Gentle to moderate slopes with broad ridges. About $1\frac{3}{4}$ mi. from canyon to main ridge.

Rate of spread types: Pure chamise 3' to 5' high.

Roads and trails: Road A-B available along the top of the main ridge and crossing it at one point north of the fire.

Values: Area is of watershed value, but acreage loss is somewhat less serious than in many other Southern California watersheds because of the rather gentle slopes which minimize erosion and the fact that the area is not very close to highly developed agricultural communities or towns.

Solution Required

Perimeter, size of fire area, and probable location at 6:00 P.M. when needed force for control is assembled and ready to go.

Acceptable Solution

1. The fire spread at a rate of perimeter increase of 40 ch. per hour. The fire was practically free-burning with a total perimeter increase from 3:00 to 6:00 P.M. of 120 ch. (3×40). Adding this to the 3:00 P.M. figure of 200 ch. gives 320 ch. total perimeter at 6:00 P.M. Area, 170 ac. at 3:00 P.M.; 520 at 6:00 P.M.
2. Fire will not reach main ridge by 6:00 P.M. because axis spread of 17 ch. per hour for 8 hours = 136 ch.

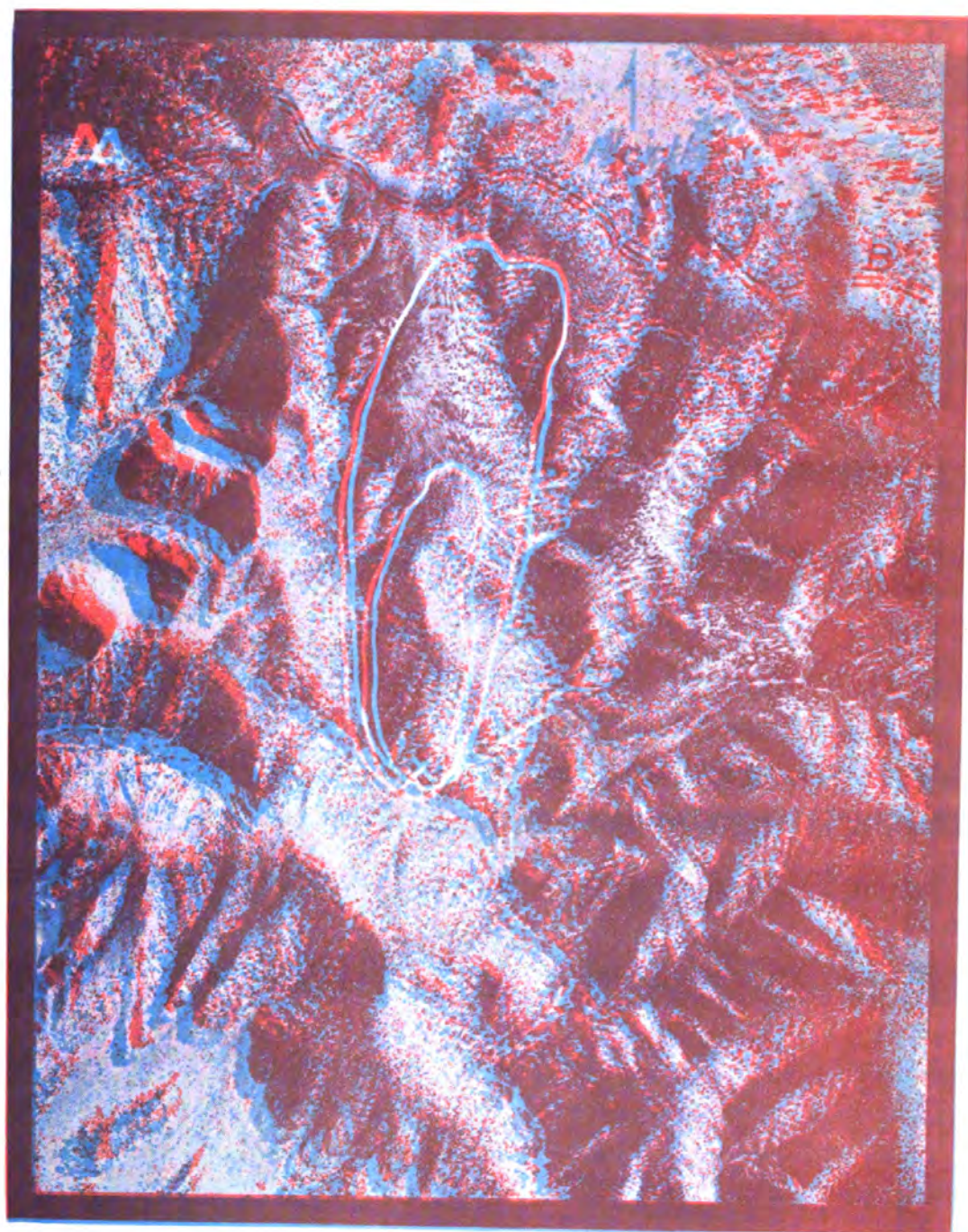


Fig. 1. (A) and (B) are the same as in Fig. 1.



Scale 1" = 56 cms.

Fig. 5

PROBABLE BEHAVIOR
HOW TO COMPUTE PROBABLE BEHAVIOR
Problem 11

Conditions

Same as for Problem 10, except

Size when planning begins: 210 ac.

Perimeter when planning begins: 225 ch. (95 ch. $\times$ 30 ch.).

Solution Required

Same as for Problem 10.

Acceptable Solution

1. Has burned 225 ch. perimeter (about 95 linear ch.) in 5 hours, or 45 ch. per hour. Has 3 hours to go, thus will create about 135 additional ch. of perimeter and 57 more ch. of axis. It will be about 95 ch. + 57 ch. = 152 ch. long, total perimeter 360 ch. with area of 600 ac. at 6:00 P.M.
2. Fire will almost surely cross main ridge unless this is effectively protected before 6:00 P.M.

PROBABLE BEHAVIOR
EFFECT OF TYPE CHANGE ON FIRE BEHAVIOR
Problem 12

Conditions

Region: East side, Zone 1.

Time of year: Mid-August

Time of day when planning begins: 2:30 P.M.

Size of fire when planning begins: 30 ac.

Perimeter of fire when planning begins: 92 ch.

History of fire to date: Origin 1:30 P.M.

Weather, current: SW. wind, 8 mi. per hour; relative humidity, 15%; fuel moisture, 4%.

Topography: Gentle, uniform slope, 8 to 10%.

Rate of spread: Fire has been burning in area cut over 3 years ago which had an original stand of ponderosa pine 20,000 ft. b.m. to the acre. Slash undisposed of. Few snags. Many rotten logs. Annual grasses have come into openings. Area ahead of fire virgin ponderosa pine, 20,000 ft. b.m. per acre, fairly free of snags. Will reach virgin timber around 3:00 P.M. when rate of spread will be but 25% of previous rate.

Values: Virgin timber area is part of working circle for sustained yield operation.

Solution Required

1. Perimeter of fire, size of fire at 6:00 P.M. when attacking forces are available.
2. Hourly rate of perimeter increase after 3:00 P.M. with head of fire uncontrolled.

Acceptable Solution

1. Perimeter of fire at 6:00 P.M. = 207 ch.
Perimeter at start of planning, 1 hour after start = 92 ch.
At same rate in same type for $\frac{1}{2}$ hour additional, 2:30 P.M. to 3:00 P.M. = 46 ch.
At $\frac{1}{4}$ the rate ($\frac{1}{4} \times 92 = 23$ ch.) for 3 hours (3:00 to 6:00 P.M.) = 69 ch.
(From Area-Perimeter Table, P. 180, General Section Fire Control Handbook) 207 ch. perimeter for a fast-spreading fire = 155 ac., size of fire at 7:00 P.M.
2. Hourly rate of perimeter increase after 3:00 P.M. = 23 ch., $\frac{1}{4}$ rate in virgin timber as in the slash. See Table 5.

PROBABLE BEHAVIOR

EFFECT OF TYPE CHANGE ON FIRE BEHAVIOR

Problem 13

Conditions

Region: East side, Zone 1.

Time of year: Mid-August

Time of day when planning begins: 2:30 P.M.

Size of fire when planning begins: 13 ac.

Perimeter of fire when planning begins: 80 ch.

History of fire to date: Origin 10:30 A.M.

Weather, current-predicted: SW. wind, 8 mi. per hour; normal humidity and fuel moisture.

Elevation: 4,000' to 4,200'.

Topography: Gentle, uniform slope 8 to 10%.

Rate of spread types: Fire has been burning for 4 hours in virgin timber and has just gone into cutover at 2:30 P.M. Cutover 3 years ago, slash not disposed of; original stand 20,000 ft. b.m. per acre.

Solution Required

1. Perimeter, size of fire at 7:00 P.M. when full attacking forces are on lines.
2. What was rate of spread per hour from 2:30 to 7:00 P.M.?

Acceptable Solution

1. Perimeter at 2:30 P.M. = 80 ch.
Hours fire has burned to 2:30 P.M. = 4.
Rate of perimeter increase per hour in virgin timber = 20 ch.
Rate of perimeter increase per hour in cutover is 4×20 or 80 ch.
(See Table 5.)
Fire spread $4\frac{1}{2}$ hours (2:30 to 7:00 P.M.) at 80 ch. per hour = 360 ch.
At 7:00 P.M. perimeter is $80 + 360 = 440$ ch.
Size of fire at 7:00 P.M. = 600 ac.
(Refer column 2, Area-Perimeter Table, page 180, in Fire Control Handbook, General Section.)
2. Rate of spread from 2:30 to 7:00 P.M. equals 4 times the rate in virgin timber or 80 ch. (See Table 5.)

PROBABLE BEHAVIOR

EFFECT OF BARRIER ON FIRE BEHAVIOR

Problem 14

USE FIGURE 6

Conditions

Region: West side, Zone 1.

Time of year: August.

Time of day when planning begins: 1:30 P.M.

Size when planning begins: 3 ac.

Perimeter when planning begins: 30 ch. (10 ch. $\times$ 5 ch.).

History: Started at 12:30 P.M. Head of fire is 10 ch. from 2-year burn when planning begins.

Weather: SW. wind, 10 mi. per hour; relative humidity, 25%; fuel moisture, 5%; weather conditions same from discovery to 7:00 P.M.

Elevation: 4,500'.

Topography: Rolling plateau with average 7% slopes.

Rate of spread types: In the dense 6-ft. brush in which fire started fire spreads 10 linear ch. per hour. In the old burn to the east fire spreads 2 linear ch. per hour. (Above rates based on fire moving with wind. Rate against wind 10% of above.)

Barriers: Recent burn as shown to east of fire marked "a."

Values: Uniform.

Solution Required

Location and area of fire when reached by suppression crew at 4:00 P.M.

Acceptable Solution

Head of fire moves NE. with wind and reaches edge of 2-year burn in 1 hour (10 ch.). It advances but 3 linear ch. in 2-year burn in $1\frac{1}{2}$ hours additional. Northwest lead of fire, however, misses 2-year burn and advances a total of 25 linear ch. through brush in $2\frac{1}{2}$ -hour run (1:30-4:00 P.M.). Total area of fire 27 acres with perimeter of 90 ch. at 4:00 P.M. when reached by suppression crew. (See long dashed line for boundary and location of fire at 4:00 P.M.)

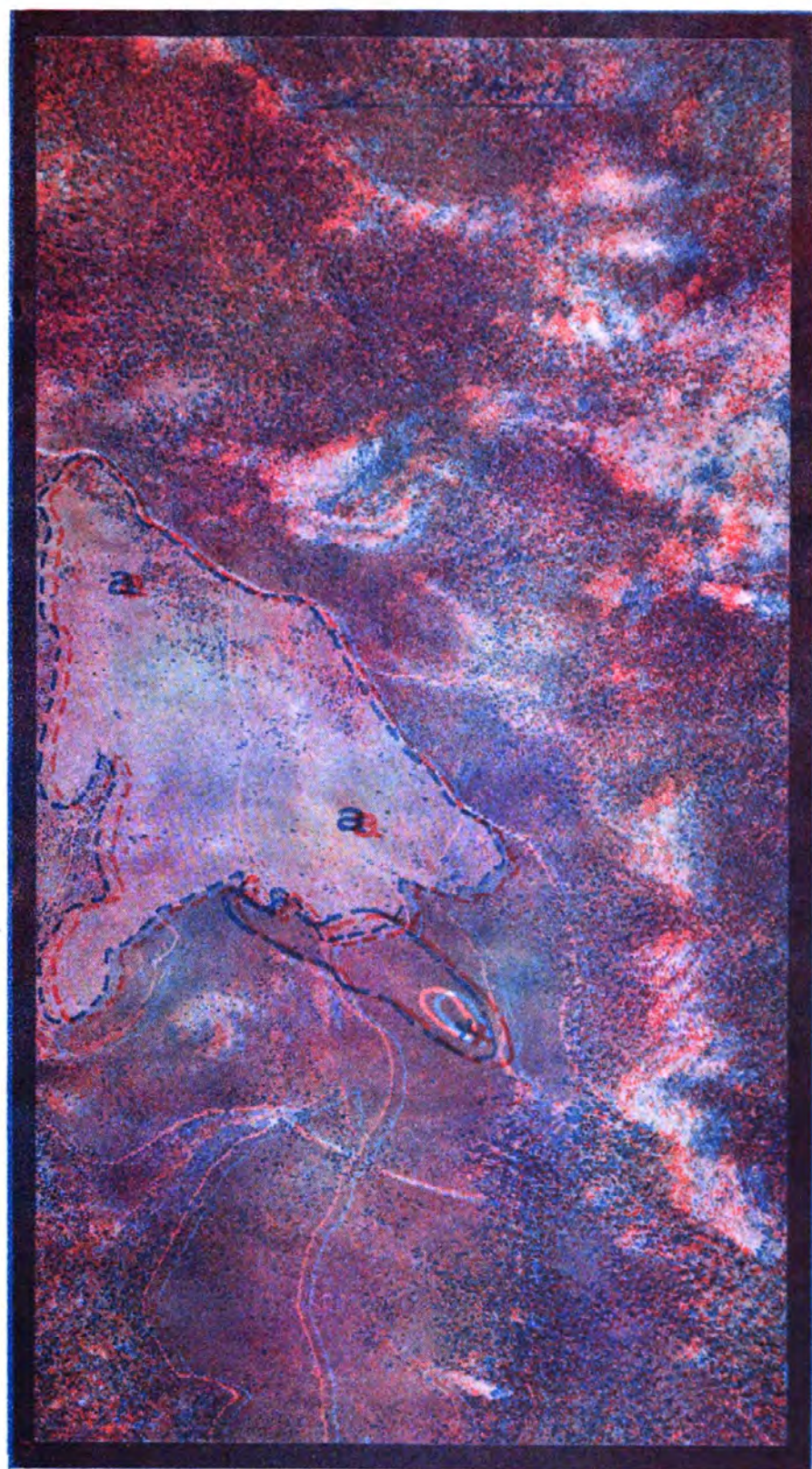


Fig. 6

Scale 3" = 1 mi.

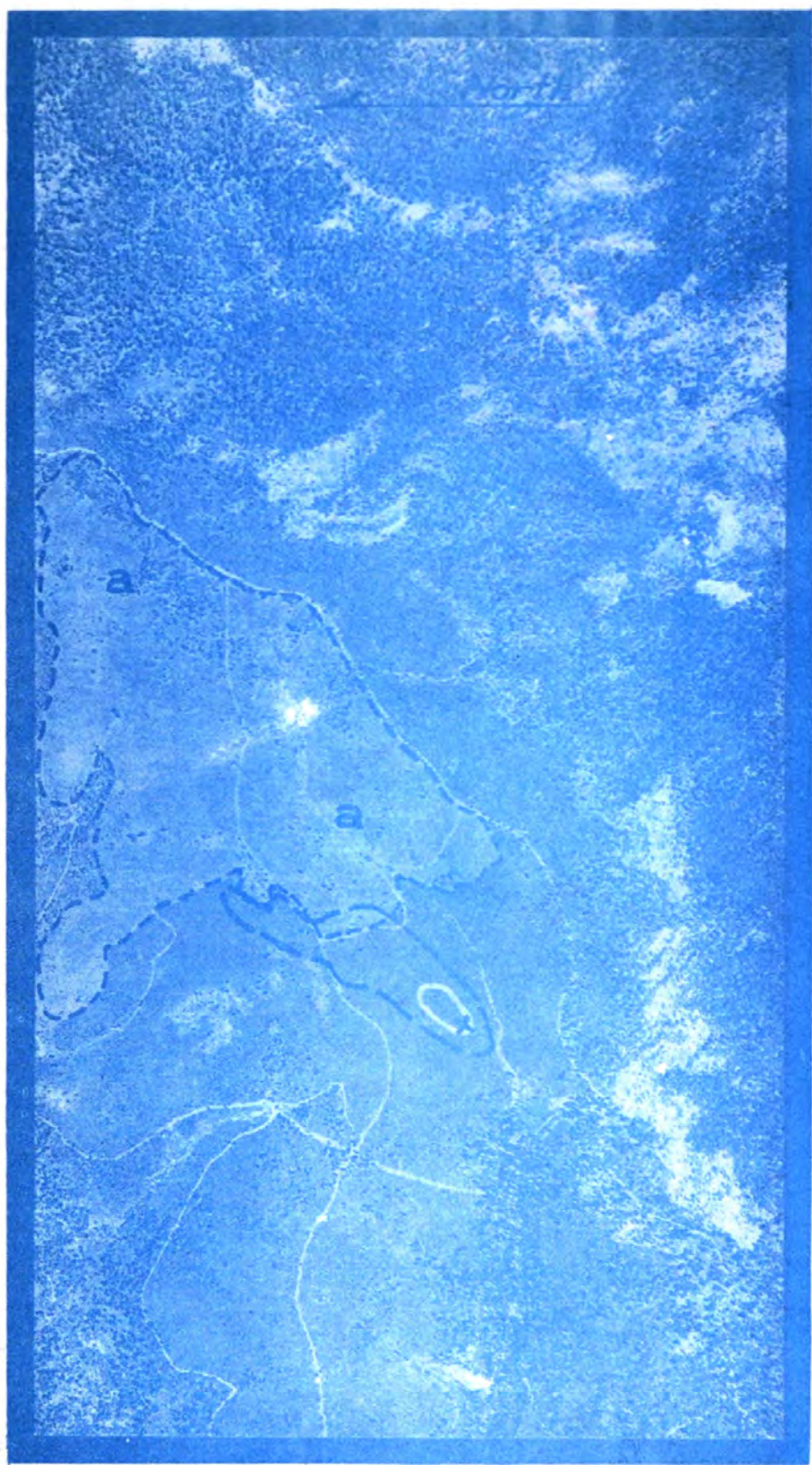
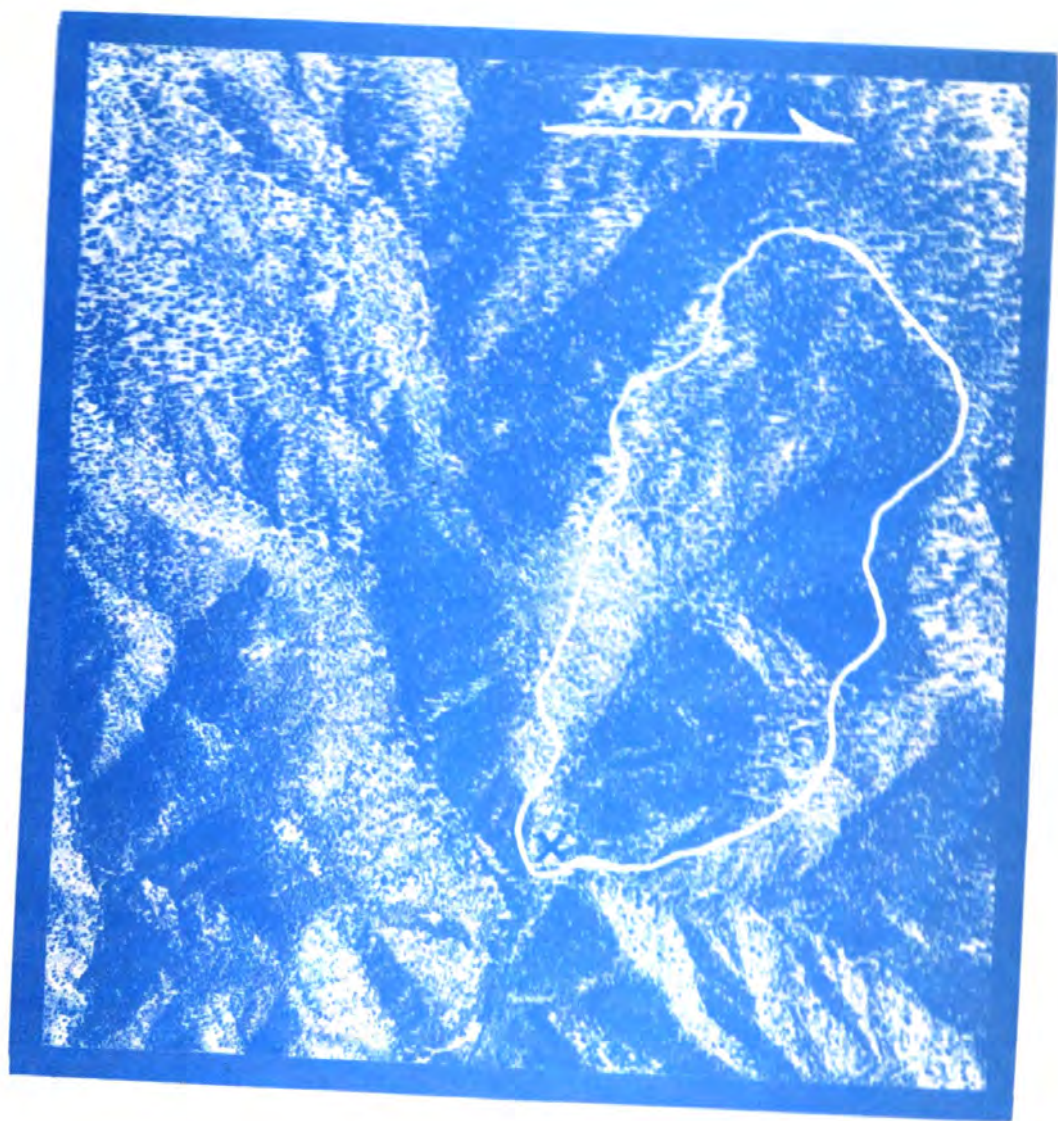


Fig. 6 Scale $3'' = 1 \text{ mi.}$



Scale 3" = 1 mi.

Fig. 7



Scale 3" = 1 mi.

Fig. 7

PROBABLE BEHAVIOR

CHANGES IN FIRE BEHAVIOR DUE TO CHANGE IN SLOPE AND TYPE

Problem 15

USE FIGURE 7

Conditions

Region: Southern California. Zone 1 at start, later Zone 2.

Time of year: August.

Time of day when planning begins: 3:00 P.M.

Size when planning begins: 155 ac.

Perimeter when planning begins: 210 ch.

History: Fire started 10:00 A.M. The first attack crew of 20 men which reached it at 10:40 P.M. was unable to handle the fire and had accomplished little by 3:00 P.M. Fire at that time had just entered timber on top of ridge. Work done from 3:00 to 6:00 P.M. was also ineffective.

Weather: Wind, 10 mi. per hour up slope; relative humidity, 10%; fuel moisture, 2.5%; slight change predicted for the better around 7:00 P.M. with reduced wind velocity and slightly higher humidity and fuel moisture.

Elevation: 2,500' to 4,800'.

Topography: Steep slopes to flat on top of wide ridges.

Rate of spread types: Chamise, manzanita and oak brush on slopes with coulter pine on ridges. In brush perimeter spread of 54 chains per hour. In timber perimeter spread of 27 chains per hour.

Roads and trails: Road on top of ridge, but none in canyon.

Values: High-value recreational country on top of the ridge. Watershed of great value because of heavy investments in dams directly below the area.

Solution Required

Determine size of fire at 6:00 P.M. when full crew is mobilized and ready to go to work. What was the perimeter at the same hour?

Acceptable Solution

1. Little or no effective work until 6:00 P.M.
2. Rate of spread in brush to 3:00 P.M. was 42 ch. per hour ($210 \div 5$).
3. Rate of spread will decrease materially when fire reaches timber in Zone 2, an estimated slowing down because of slope to 25% and for type a further reduction down to $12\frac{1}{2}\%$. $42 \times 12\frac{1}{2} = 5\frac{1}{4}$ ch. perimeter increase per hour for fire in timber. (See "Changes in Rate of Spread" table of ratios.)

4. Between 3:00 and 6:00 P.M. rate of spread would be $5\frac{1}{4}$ ch. $\times$ 3 hours or about 16 chains.
5. Total perimeter at 6:00 P.M. would then be that produced up to 3:00 P.M. or 210 ch. plus the 16 ch. produced between 3:00 P.M. and 6:00 P.M. or total of 226 chains. (This does not include the slight perimeter increase along flanks during this period.)
6. Total acreage corresponding to 226 ch. perimeter is 180 acres. (See Column 2, Area-Perimeter table, Fire Control Handbook, page 180, General Section.)

PROBABLE BEHAVIOR

BASIS FOR CALCULATING PROBABLE BEHAVIOR WHEN FIRE NOT DIRECTLY VISIBLE AND MEASURABLE

Problem 16

Conditions

Region: Northwest California.

Time of year: September

Time of day when planning begins: 2:00 P.M.

Size of fire when planning begins: Unknown.

Perimeter of fire when planning begins: Unknown.

History to date: Start unknown, discovered 1:45 P.M. Fire in deep canyon, invisible to lookouts. No local people to give information. Lookout says probably on north side of canyon near river.

Weather, current: Class 4 day.

Predicted: No change till 6:00 P.M.

Elevation: 2,000' canyon bottom, 4,000' top of ridge paralleling canyon.

Topography: Moderate $1\frac{1}{2}$ mi. from canyon to ridge (25% slope).

Rate of spread types: Zone 1 if fire on south slope where it appears to be.

Barriers: None.

Solution Required

Probable perimeter and area at 4:00 P.M. when full attack can be mobilized.

Acceptable Solution

1. Probably has burned 2 hours before discovery at 1:45 P.M.—past experience.
2. Average rate of perimeter spread for region 23 ch. per hour. (See Table 1, Basic Spread Rates.)
3. Probable perimeter at 2:00 P.M. $2\frac{1}{4} \times 23 = 52$ ch.; area 9.5 ac. (See Col. 2, Area-Perimeter Table, Fire Control Handbook.)
4. Probable perimeter at 4:00 P.M. 98 ch. ($4\frac{1}{4} \times 23$); area 30 to 40 ac. Probable length 30 to 35 ch.

5. Fire will be long way from main ridge at 4:00 P.M. Not expected to approach ridge before change in weather at 6:00 P.M. (At same rate of spread as from start to 4:00 P.M. fire would not reach ridge until approximately 17 hours after start (11:45 A.M. - 4:45 A.M. of next day) provided fire started at extreme base of canyon.)
-

POINTS TO CONSIDER IN PROBABLE BEHAVIOR

1. Character and density of cover in which fire is burning and which is in its path. Rate of spread types. Special hazards.
2. Slopes on which fire is burning and which it may reach.
3. Danger rating.
4. Weather conditions that exist and are predicted or expected for rest of period.
5. Time of day—duration of current conditions.
6. Actual rate of spread of individual fire up to time planning begins.
7. Average rates of spread in different regions.
8. Presence or absence of barriers to slow up or stop spread.

TIMING

Understanding of timing fire control operations is a major part of the qualifications possessed by a successful fire boss. He must be able to correctly select the sector for first attack, and to decide on the timing and order of attack on other sectors. He must time his backfire on individual sectors, and be able to decide on timing and order for backfiring several sectors. He must in other words keep the timing of all parts of a complex campaign in such relation to each other that one part will not nullify another or that one may not fail to supplement another.

The problems in other sections, particularly those for selecting sector for first attack and for backfiring, illustrate the vital role of timing.

EMERGENCY ACTION

Foreword

Prompt and vigorous action is needed on many fires that have escaped initial attack so as to bridge the gap between the time the fire breaks away and when the full attack gets under way. By a well-timed effort with a relatively small force at a strategic point the forward rush of the fire can perhaps be stopped or materially delayed by a well-placed backfire. This will reduce the size of the job and will often make possible first-night control with a margin of safety, rather than a nip and tuck battle that may leave some of the lines in such shape they stand little chance of holding as burning conditions get more difficult the next day. Similar emergencies may develop during large fires when a bold stroke will give more than an even chance of success if well conceived and promptly executed.

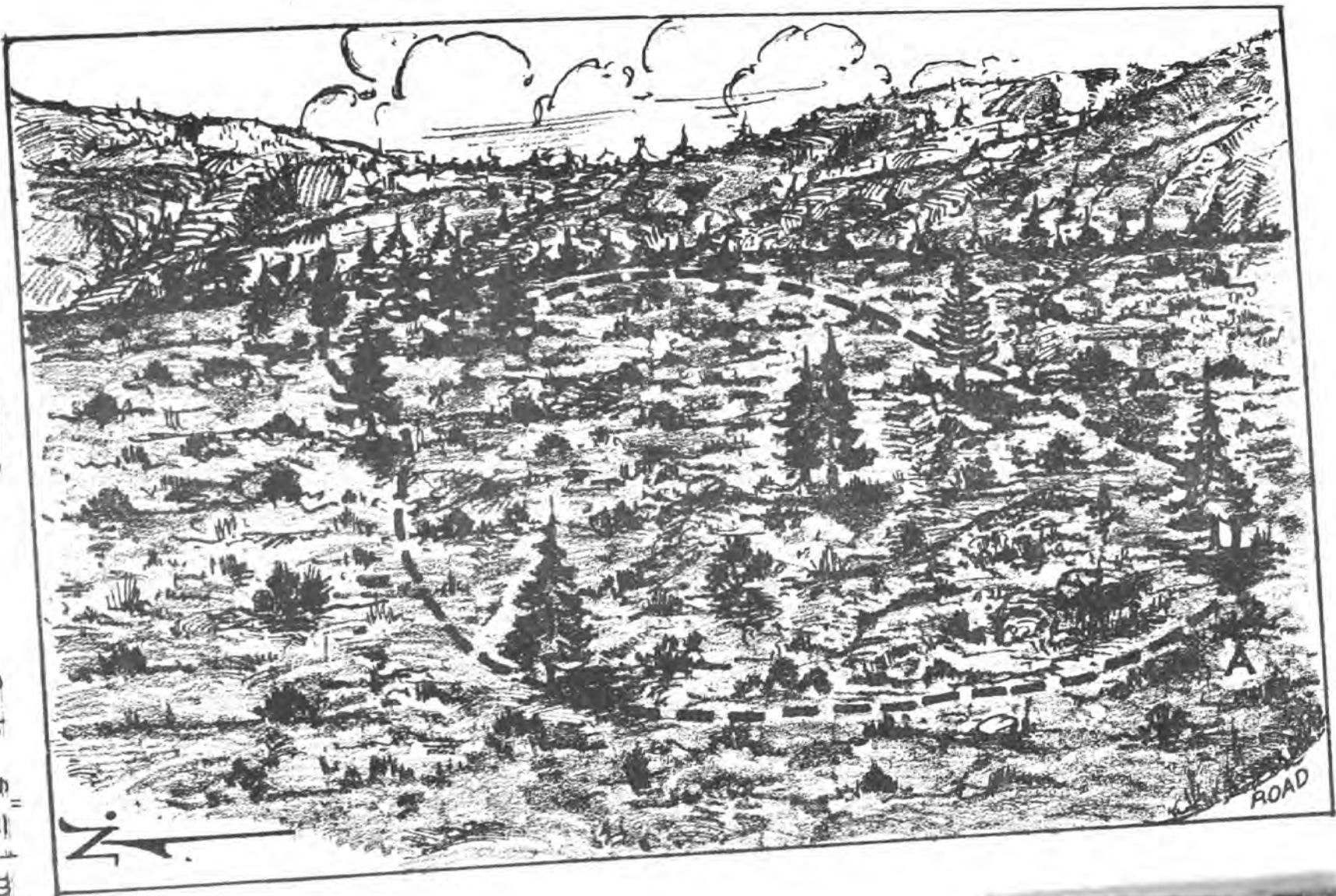


Fig. 8

Scale 6" = 1 mi.

SPECIAL EMERGENCY ACTION

Problem 1

USE FIGURE 8

Conditions

Region: East side, Zone 1.

Time of year: August

Time of day when planning begins: 4:15 P.M.

Size of fire when planning begins: 105 ac.

Perimeter of fire when planning begins: 165 ch.

History of fire: Fire started at 3:24 P.M. No action to control fire except small crew made effort to handle run that had taken place. Ranger arrived with a crew of 14 men at point A.

Weather: Light NW. wind; relative humidity, 10%; fuel moisture, 2.5%.

Elevation: 4,000'.

Topography: Level.

Types: Open, sagebrush and very scattering ponderosa pine timber.

Barriers: There was a narrow road with some down material along it approximately at right angles to the fire's front, perhaps 20 minutes ahead of the fire, at 4:15 P.M.

Equipment available: A tank truck and 200 gallons of water on the road at A.

Manpower available: Initial attack crew of 5 men working on the rear and 14 men on the road on fire's head with no more forces within reach before early nightfall.

Solution Required

What might fire boss do on the chance he could stop or delay materially forward spread of the fire and perhaps reduce its ultimate area very decidedly?

Acceptable Solution

It was apparent that with the very rapid existing rate of forward spread a large fire was in prospect unless something decisive was done at once. The fire boss should backfire from the road toward the advancing front of the fire. Backfiring can be done safely, and if it fails he has lost nothing. This is the only possibility of cutting fire off before the full force was available that night. If this maneuver is successful the problem of catching up the sides is still a very live one, but may be accomplished with the men and water available.

SPECIAL EMERGENCY ACTION

Problem 2

USE FIGURE 9

Conditions

Region: Northern California.

Time of year: Mid-August.

Time of day when planning to control head of fire begins: 6:00 P.M.

Size of fire at 6:00 P.M.: 1,300 ac. (includes area burned out on flanks and rear).

Perimeter of fire at 6:00 P.M.: 532 ch. of which 200 ch. across the head.

History of fire: The fire started at point (x) at 4:00 P.M., August 15, was discovered 15 minutes later with an estimated area of $\frac{1}{4}$ acre. The fire immediately began spreading rapidly in an east to northeast direction. The dispatcher immediately realized that the fire would be difficult to control so dispatched a large crew to attack it. This crew under the direction of the fire boss attacked and controlled the heel and flanks of the fire along roads A-B, A-I, and I-G, recognizing that the head was too hot to handle. By 6:00 P.M. they had been able to control three sides of the fire; sides A-B, A-I, and I-G. The head of the fire, line B-G, was not controlled by 6:00 P.M. nor had any line been constructed on this sector.

The lay of the fire at 6:00 P.M. is shown on the anaglyph by lines A-B-G-I-A.

At 6:00 P.M. 110 fresh men with overhead and full equipment arrived at point D. The fire boss met them at this point.

Current weather: Prevailed during the day as follows: West to southwest wind, 8 mi. per hour; relative humidity, 15%; fuel moisture, 4%.

Predicted weather: Slightly lower wind conditions may be expected during the forepart of the night, but by 11:00 P.M. it is expected to pick up again, attaining a velocity of 20 mi. per hour by midnight which will continue for the following 24 hours. The direction will be unchanged. The relative humidity and fuel moisture will remain unchanged.

Elevation: Main ridge 4,800'. Canyons and draws 500' to 1,000' lower in elevation.

Topography: General drainage to SW. Slopes gentle to moderate except south of road E-F where steep slopes are encountered.

Rate of spread types:

Area (a) mature ponderosa pine, douglas fir, scattered brush.

Area (b) mixed brush, some scattered timber.

Area (c) grass, few clumps of valley oaks.

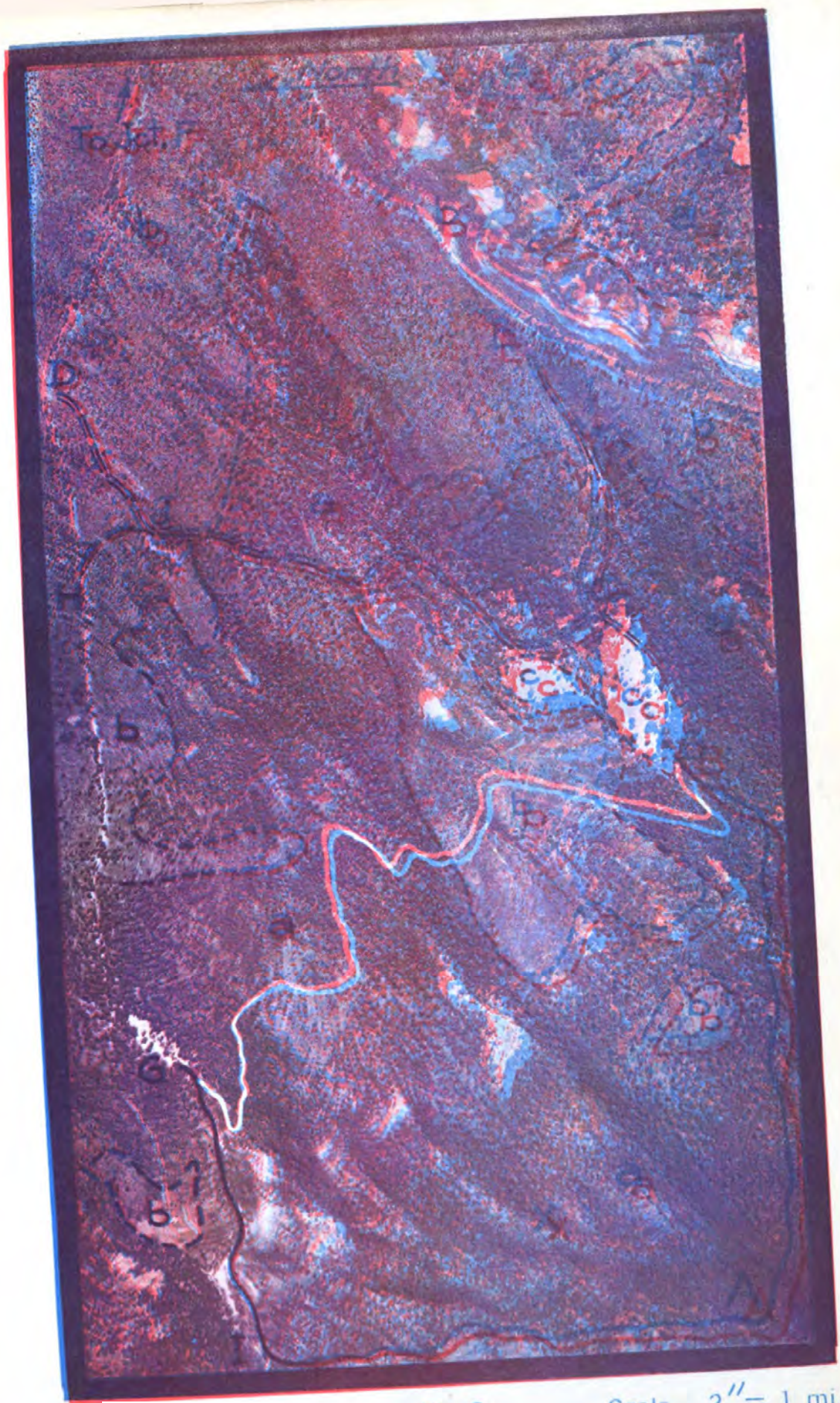


Fig. 9

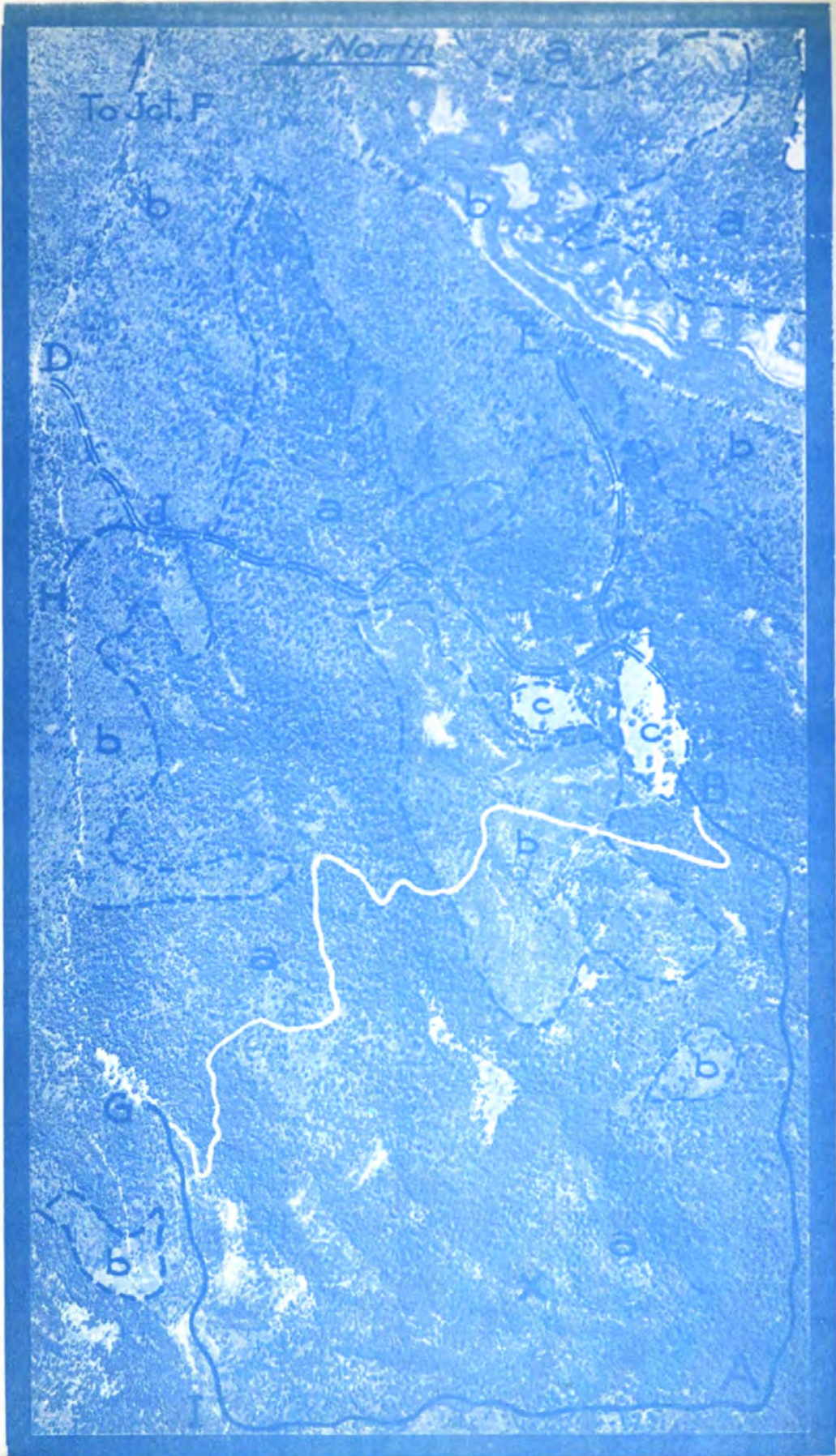


Fig. 9

Scale $2'' = 1 \text{ mi.}$

Water available:

- Point C—Tanker supply.
- Point G—Tanker supply.
- Point D—Tanker supply.

Barriers: None.

Manpower available: Excepting the men that are actively engaged in holding the line already constructed, B-A-I-G, 110 men are at point D and available for work; 100 more are to arrive by midnight.

Equipment available: 2 tankers at point C—capacity 300 gals. each; 2 tankers at point G—capacity 300 gals. each; 1 RD-7 at point D; and all backfiring and other equipment necessary for control is available at point D.

Roads: Roads are located:

- A to I to D to F.
- A to B to C to E to F.
- C to D.
- Speeds 15 to 20 miles per hour.

Solution Required

How to attempt control of a fast-spreading fire even if there is possibility emergency plan of action may fail.

Acceptable Solution

The fire boss in sizing up the situation visualizes three possibilities, namely:

- a. Control head of fire by direct attack, building line ahead of B-G (approximately 200 ch.).
- b. Hold road from G to H, thence possible trailbuilder line H to J, thence road from J to B.
- c. Hold roads from G to F; from F to E; from E to B.

He decides that direct attack on head of fire is not possible since the manpower is not sufficient to make such an attack under the conditions of weather and fuel types and resultant expected rate of fire spread.

This leaves only two solutions available, (b) and (c). In deciding between the two he knows that the lead of the fire has progressed 1 mi. forward in 2 hours. (No appreciable change in type ahead of main lead.)

The velocity of the wind is predicted to become slightly lower for the next four hours, but will increase steadily after that until midnight when it will reach a maximum velocity of 20 mi. per hour.

The fire boss calculates that the head of the fire will not reach the line J-H inside of $1\frac{1}{2}$ hours; that in any event he will have to hold road G-H since the area to the north once the fire crosses this road does not have any control points for miles. Also that he will have to hold road B-C in either case.

This leaves him the choice between roads C-J, line J-H, and road C-E-F-D-H.

He chooses to backfire immediately the line G-H-J-C-B and not line G-D-F-E-C-B. The reasons for this choice follow:

1. 700 acres in area would be saved from burning if this attack is successful.
2. $3\frac{1}{2}$ mi. of line were involved in solution (b) as compared to 6 mi. in solution (c). Type along road C-J is easier to backfire than type along road D-F-E (timber versus brush).
3. No hand line construction needed since line J-H will be built by tractor and remainder of line G-H-J-C-B has roads for line. Fire line can be held by 3 men per 10 chains (no men needed for holding 20 chains of grass type, line B-C; hence, line construction and holding job will take approximately 75 men (260 ch. @ 3 men per 10 ch.). Based on experience, backfiring, handling tank trucks, and operating trailbuilder on this line will take 35 men. Since there are only 110 men available, a longer line construction and backfiring job within the available time would have little chance of success.
4. If line C-J-H were lost he could still back up to line C-E-F-D-H.

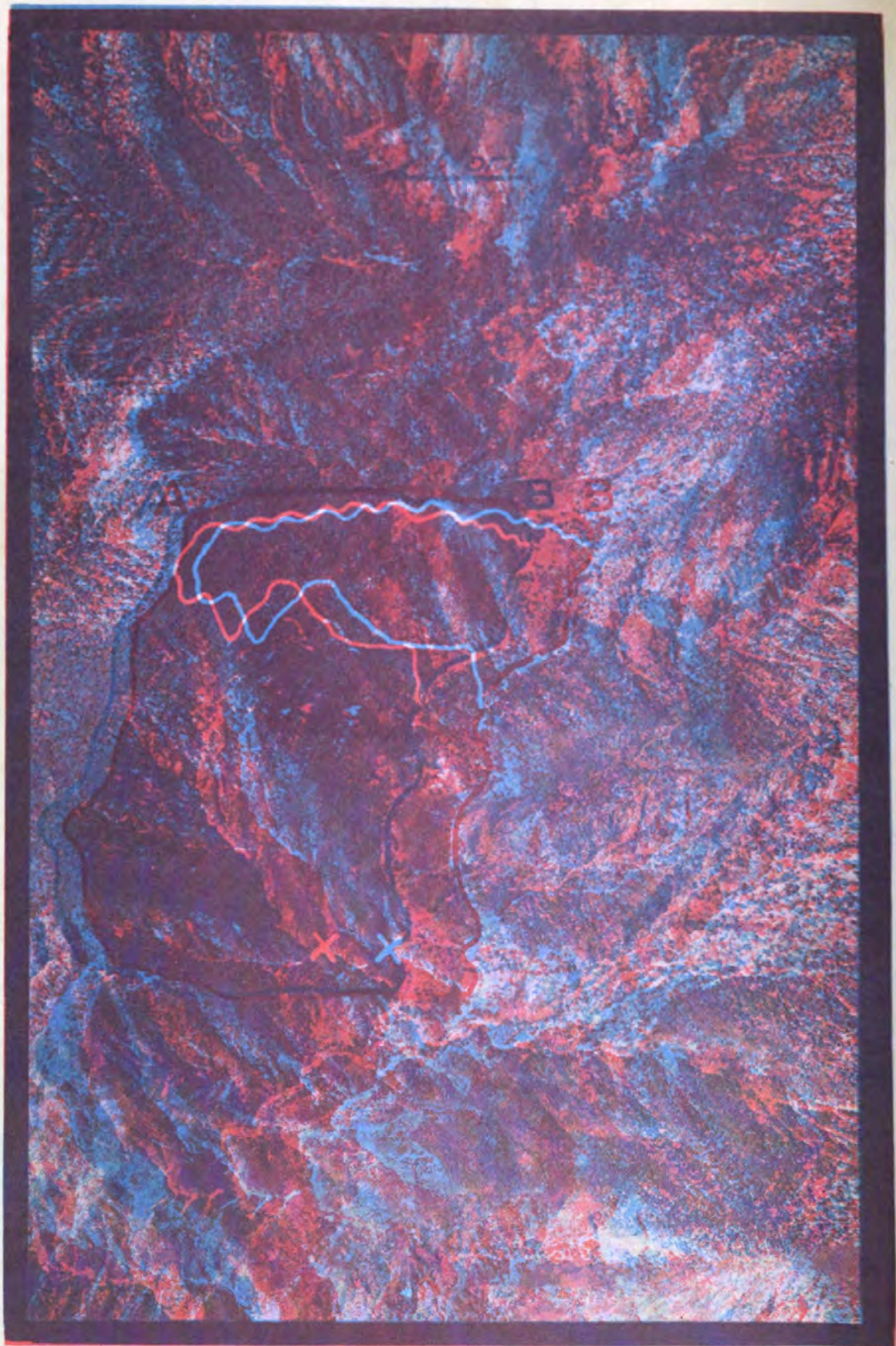


Fig. 10

Scale 3" = 1 mi.

SPECIAL EMERGENCY ACTION

Problem 3

USE FIGURE 10

Conditions

Region: South Central Coast Range, Zone 1.

Time of year: September.

Time of day when planning begins: 4:00 A.M. of day subsequent to the day fire started.

Size of fire when planning began: 240 ac.

History to date: The fire was worked upon with all available men and controlled with the exception of approximately 50 ch. of built line into the river. The line was built through knobcone pine and brush and backfired beginning at 2:00 A.M. The backfire did not burn back at all well and stopped running at 3:00 A.M. The main fire was then 10-20 ch. back down the river (west) from the backfired line A-B.

Predicted weather: No change from normal average bad burning conditions predicted for next day.

Topography: High ridge between two main canyons above junction.

Barriers: River is only a fair barrier against free running fire though not too effective because of a few minor interlocking points. A safe backfiring line.

Manpower available: Forces were inadequate to handle the patrol and mop-up on the fire, and hopelessly inadequate to handle strong runs up against the poorly fired-out line, A to B.

Solution Required

What might the fire boss have done at 4:00 A.M. of the second day to prevent the run of the main fire that later that day came with such force as to sweep across the weak backfired line A-B?

Acceptable Solution

Granting the east line was weak with a narrow-burned area in front of it, there was a decided chance that this could have been held by prompt firing out of the river at 4:00 A.M. of second day, starting at the backfired line at point B, using effective backfiring equipment such as flame throwers. The down-canyon wind would have kept backfire from hitting east line hard. The uphill backfire would have burned more severely than the downhill backfire along the east line. Water and a portable pumper were available to help keep the fire from jumping across on the interlocking points along river. This might have removed enough of the cover between the east backfire line and main fire so that the main run of the fire would have played out before it reached the line. Unless the chance was taken the fire was bound to escape over line A-B when the normal change to up-canyon wind came later that morning.

SPECIAL EMERGENCY ACTION
EMERGENCY BACKFIRING OF FIREBREAK ON SHARP RIDGE

Problem 4

USE FIGURE 11

Conditions

Region: Southern California.

Time of year: September.

Time of day when planning begins: 4:00 P.M.

Size of fire when planning begins: 600 ac.

Perimeter of fire when planning begins: 540 ch. (approximately 230 ch. linear distance).

History to date: Start 1:00 P.M. First attack at rear 1:30 P.M. held; subsequent crews worked both flanks up from rear and held around 40 ch. on each flank, B-C. Fire within 80 ch. linear distance of main ridge. Fresh reinforcements to be available at 4:15 P.M.

Current weather: South to southwest wind, 6 mi. per hour; relative humidity, 15%; fuel moisture, 3%.

Predicted weather: Continue with normal daily fluctuations.

Elevation: 500' at base, 3,500' on ridge.

Topography: Steep slopes on both sides of sharp ridge in badly broken country.

Rate of spread types: Heavy brush on both sides of main ridge.

Barriers: Cleaned firebreak along main ridge.

Water available: Catchment basin on truck trail near main ridge (point A).

Manpower available: 80 fresh men coming in, to be available at fire at 4:15 P.M. Point A; crews on rear and flank have to stay on those jobs.

Equipment available: 2 tankers can be put on main ridge firebreak. Also backfiring equipment, Point A.

Roads and trails: Truck trail taps main divide, Point A, firebreak 20 ch. east of approximate point where fire will first hit ridge.

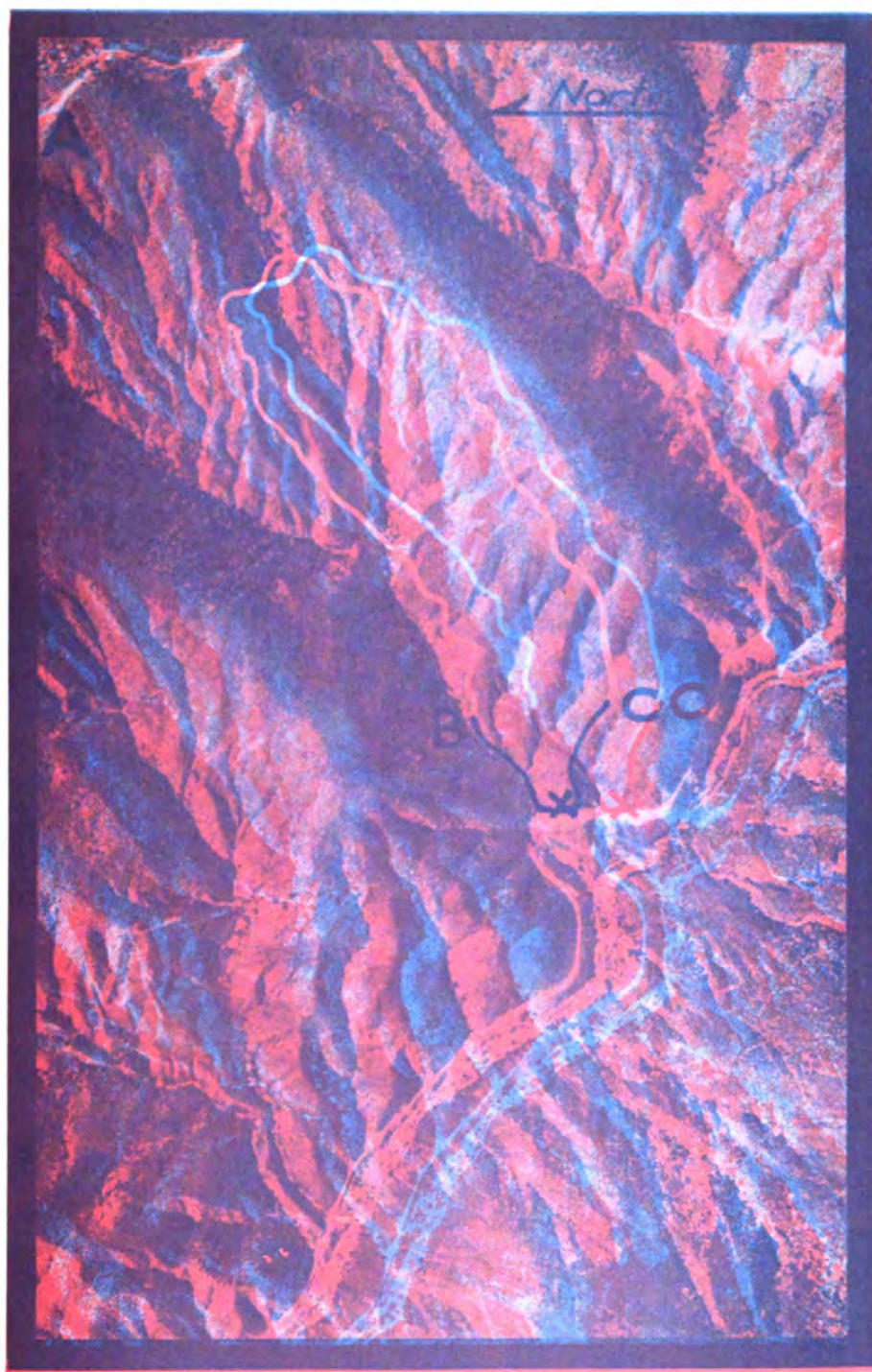
Values: Opposite slope extremely high watershed values.

Solution Required

Where and how to use the fresh reinforcements and available special equipment.

Acceptable Solution

1. At present rate of spread, fire will reach main divide at or immediately after 5:00 P.M. (80 ch. linear distance and head of fire moving at rate of 77 ch. per hour) on a front of 30-50 ch., not all at one time but progressively because of broken topography.



Scale 1" = 1 mi.

Fig. 11



Scale $1'' = 1 \text{ mi.}$

Fig. 11

2. Firebreak cannot be expected to hold automatically. Use of men and tankers without backfiring not likely to hold.
 3. If fire breaks over and becomes established on opposite slope, country is so steep and cover so heavy that final control lines for fire front will probably have to be in gulch at bottom of opposite slope. This will about double acreage, increase length of suppression job, and involve a large and tricky backfiring job.
 4. Spread fresh crew with backfiring equipment and tankers and backfire main divide firebreak during next hour.
 5. This is the thing to do right now. It will probably stick. If it doesn't, little is lost that would not be lost in any event. If it does stick, the flanks can be tied in during the night and early morning.
-

POINTS TO CONSIDER IN EMERGENCY ACTION

1. When a road or other barrier, which will not in itself stop a fast-moving fire, lies directly in the path of such a fire, always consider setting a free backfire if there is a fair chance of stopping the main axis of spread, even though the flanks are not simultaneously controlled.
2. When there is a poorly burned-out backfire line running up and down slope, time early morning, conditions of previous day forecast for current day, consider backfiring up slope along the line in order to get free spread and clean burn. The alternative of waiting and trusting that the main fire will not sweep over the poorly burned backfired line, when conditions get bad later in the day, is usually a sure way to lose the line. If weather conditions are to improve so that main fire will be quiet, the acceptable alternative is usually to cold trail both main fire and backfire.
3. When a shortage of forces necessary to construct lines where the surest location to hold exists, consider line location that can be constructed with available forces, even though it is less certain to be held. Plan should be made for alternative course of attack should the initial attempt fail.

LINE LOCATION

Foreword

On most fires there are several possible locations for the control lines. Many factors, varying from fire to fire, need to be weighed in making decision as to which location will be most effective. Choices based on rule of thumb are likely to turn out badly. Intelligently selected locations are those which successfully accomplish the particular job by holding as planned.

The group of problems illustrates the more common situations met in practice, on which accurate judgment is required.

LINE LOCATION

LOCATING LINE TO TAKE ADVANTAGE OF MAN-MADE OR NATURAL BARRIERS

Problem 1

USE FIGURE 12

Conditions

Region: West side, Zone 1.

Time of year: Mid-July.

Time of day when planning begins: 7:00 P.M.

Size of fire when planning begins: 60 ac.

Perimeter of fire when planning begins: 130 ch.

History to date: Fire started below the road at point (x) at 5:00 P.M. and had spread as shown by heavy white line. It was burning slowly upon arrival of fire boss at 7:00 P.M.

Current weather: Wind, up slope, less than 1 mi. per hour; relative humidity, 30%; fuel moisture, 5%; no predicted change next 12 hours.

Elevation: Base of fire 5,000'. Ridge above fire 5,500'.

Topography: Fire is located in the upper reaches of a small drainage; slopes steep; numerous small draws; well-defined ridge ahead (south-east) of fire.

Rate of spread types: South portion of area ponderosa pine and brush; north portion mostly heavy brush.

Barriers: Natural—B-C, D-E, E-F, G-H-I.

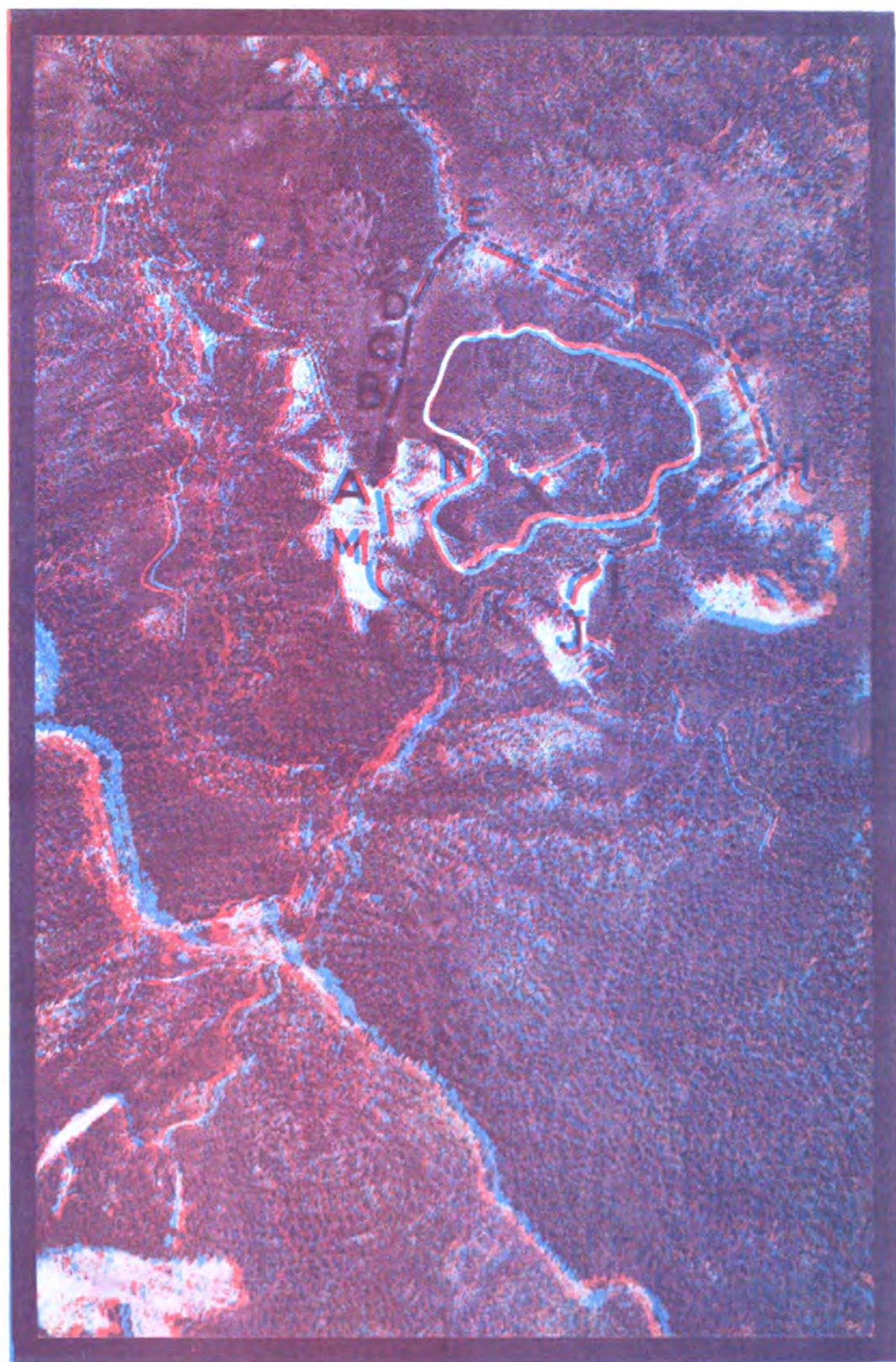
Man-made—A-N-M, I-J.

Semi-barriers—M-L, L-K, K-J.

Manpower available: Sufficient.

Equipment available: Sufficient.

Roads: A-J through fire area.



Scale 3'' = 1 mi.

Fig. 12



Scale 3'' = 1 mi.

Fig. 12

Solution Required

Where to locate lines to reduce job of construction through use of all possible available barriers.

Acceptable Solution

Starting from point A, follow semi-barren ridge to E, thence along main semi-barren ridge to H, thence down shallow semi-barren draw to I, thence along man-made barrier to J, thence down semi-barren draw to K and L and up semi-barren draw to M, thence use man-made barrier to A, point of beginning.

Through use of such barriers it was possible to reduce the line-construction job from 216 ch. to 27% of this distance. A going fire perimeter of 115 ch. (heavy white line) is surrounded by an adequate fire line through use of available barriers by 31 ch. of line construction A-B, C-D, F-G and 30 ch. of only partial line construction L-M, J-K, K-L, making a total of only 60 to 65 ch. of actual line construction.

Supplemental

Lakes, rock slides, cleared fire breaks, etc., are also barriers and should be used to the fullest extent possible in the location of fire lines.

LINE LOCATION

SHORTENING CONTROL LINE TO EFFECT RAPID CONTROL, TO REDUCE
DIFFICULTY OF LINE CONSTRUCTION, TO REDUCE LINE
HOLDING, MOP-UP AND PATROL JOB

Problem 2

USE FIGURE 13

Conditions

Region: West side, Zone 1.

Time of year when planning begins: Late September.

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: 175 ac.

Perimeter of fire when planning begins: 250 ch.

History to date: Fire started at point (x) at 2:00 P.M. The initial attacking force of 5 men and one squad tanker arrived at the fire 40 minutes later. The fire on arrival was 40 acres. They immediately recognized that with forces available they would not be able to attack the head of the fire, so began working the heel and the south flank, using the road G-B-C as a control line from which to backfire. The Ranger arrived at 5:00 P.M. and found that control lines were being held along the road from point G to point C. He also saw that the fire was fingering very badly on the north flank (F to G); that it was burning very slowly up the slope on the north flank towards the ridge E-A as well as spreading slowly to the east.

Current weather: West to southwest wind, 6 mi. per hour; relative humidity, 27%; fuel moisture, 5%.

Predicted weather: No material change except that at 10:00 P.M. the wind will change direction to east and northeast.

Topography: Slope gentle over fire area except to the north of ridge A-E which is steep into dry creek I-H.

Rate of spread types: Heavy manzanita over fire area with scattered islands of ponderosa pine.

Water available: Point D.

Manpower available: Excluding initial attacking force, 50 men at point D at 5:00 P.M.

Equipment available: Two RD-7 trailbuilders, backfiring and other hand equipment at point D.

Roads: Roads A to B to D.

Solution Required

Best location of control lines to speed up control, to use easiest routes, and to reduce line holding, mop-up, and patrol jobs.

Acceptable Solution

1. Use and hold line on road from G to C, extending line along road C-D; total 115 ch.
2. Use tractors to build D-E-A along ridge, thence use road from A to G; total 95 ch. Impracticable to build line to run around all fingers. Line used is 40 ch. shorter, is on location that is easy to hold and patrol. Facilities inadequate to construct closer-in line through heavy brush in reasonable time.



Scale 3" = 1 mi.

Fig. 13



Scale 3" = 1 mi.

Fig. 13

LINE LOCATION

EVERYTHING ELSE BEING EQUAL, LINES SHOULD BE LOCATED WHERE
THE LEAST AMOUNT OF EFFORT WILL CONSTRUCT THEM

Problem 3

USE FIGURE 14

Conditions

Region: West side, Zone 1.

Time of year: Mid-August.

Time of day when planning begins: 7:00 P.M.

Size of fire when planning begins: 320 ac.

Perimeter of fire when planning begins: 320 ch.

History to date: Fire started at point (x) at 3:00 P.M. Pushed by a 4-mile up-slope wind it spread as shown by 7:00 P.M. The first attack force of 10 men had failed to hold any of the line constructed except line from A to B a distance of 100 ch. When the fire boss arrived at 7:00 P.M. the spread of the fire had slowed down considerably.

Weather, current: Westerly wind, 4 mi. per hour; relative humidity, 28%; fuel moisture, 5%.

Predicted: Wind is predicted to change direction slowly from west to east. Wind will be easterly by 10:00 P.M. No change in velocity. Relative humidity will rise slowly from 28% to reach 35% by midnight, at which point it will remain during the night.

Elevation: 4,500'.

Topography: The area slopes gently; no deep canyons or sharp ridges.

Rate of spread types:

Area (a)—Dense manzanita.

Area (c)—Mature ponderosa pine, heavy stand.

Resistance to line construction types:

Area (a)—Dense manzanita, .7 ch. per man-hour.

Area (b)—Barren, no men needed.

Area (c)—Mature ponderosa pine type, 4.6 ch. per man-hour.

Barriers:

Area (b)—Placer diggings.

Manpower available: All necessary by 7:00 P.M.

Equipment available: Hand tools and backfiring equipment only.

Values: Mature ponderosa pine surrounding brushfields—high value.

Solution Required

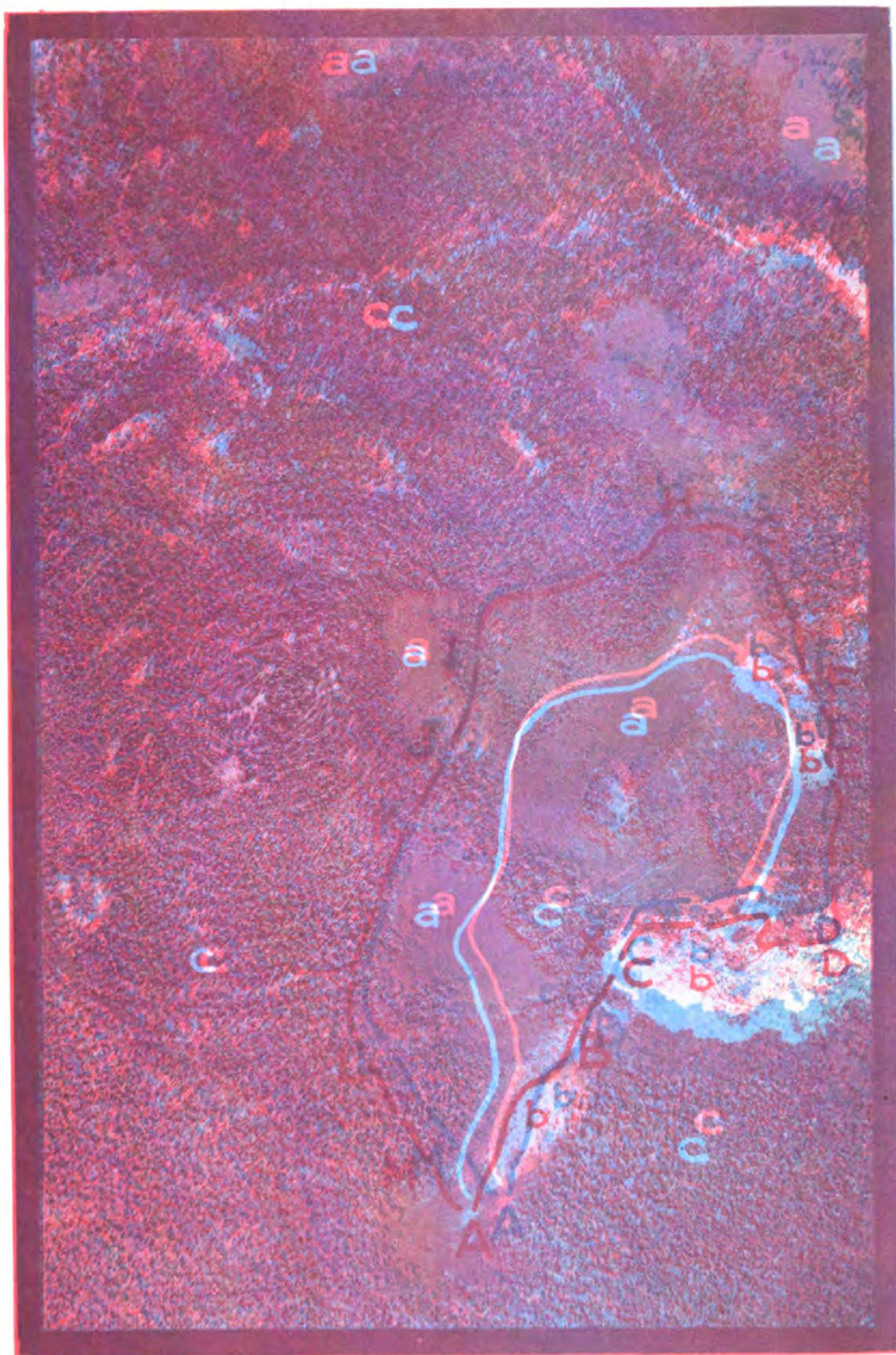
Best location of lines to secure maximum ease and speed of control.

Acceptable Solution

1. Utilize barriers formed by placer digging (b) to extent possible in locating line.
2. Utilize timber rather than brush type for location of line to extent possible.
3. Brush line from A to M. Timber line from M to L to K to J; work through stringer of timber from J to I, thence through timber from I to H, thence through short stringer of brush from H to G, thence timber line from G to F. Utilize barriers at F and E with line through timber between these points and to point D; thence to C, using barrier, through timber C to B and use barrier B to A.

Construction of line in timber requires less manpower than attempting to construct it through brush. With a relative humidity of approximately 28% to 35%, it is much easier to burn out a line in timber with a ground cover of pine needles than a line in brush. Natural barriers should be used whenever possible to reduce amount of work and to assure quicker control. No appreciable change in topography, hence it is not a factor in this problem.

Some of the lines are undercut but the slope is not severe enough to cause difficulty if correct technique is used in constructing lines.



Scale 2" = 1 mi.

Fig. 14

LINE LOCATION

SELECTION OF EASIER LINE LOCATIONS, TAKING ADVANTAGE OF TOPOGRAPHIC BREAKS

Problem 4

USE FIGURE 15

Conditions

Region: West side, Zone 1.

Time of year: Late August.

Time of day when planning begins: 2:30 P.M.

Size of fire when planning begins: 30 ac.

Perimeter of fire when planning begins: 90 ch.

History to date: Fire escaped from initial attack and has burned 2 hours with fireman doing what work he can at rear of fire. Fire well established on both sides of shallow ravine (s).

Weather, current: SW. wind, 12 mi. per hour; humidity, 20%; fuel moisture, 4.5%.

Elevation: 3,000' at point B; 3,800' at point E, top of ridge.

Topography: Steep timbered side hill rising to a lateral ridge with one main ravine and minor side gulches.

Rate of spread types: Light grass area (n), mature ponderosa pine with some reproduction on slope where fire is heading; cultivated areas (m), grass and scattered brush along power line D-A and along telephone line A-B.

Barriers: Cultivated land area (m). State highway at canyon bottom, point B, cultivated fields adjacent and NW. of State highway. Partial barriers line D-A, cleared power line with grass and scattered brush; A-B, cleared telephone line with grass and scattered brush; (n) to E to F old trail, 4' clearing; F-C, old road, 8' clearing.

Manpower available: 50 men.

Equipment available: Necessary hand tools only and backfiring equipment.

Roads and trails: Horse trail 4' clearing from grassy flat at A southwest to point of ridge at E. Old trail E to F. Road F-C.

Solution Required

Location of control lines with due consideration to topography and available barriers.

Acceptable Solution

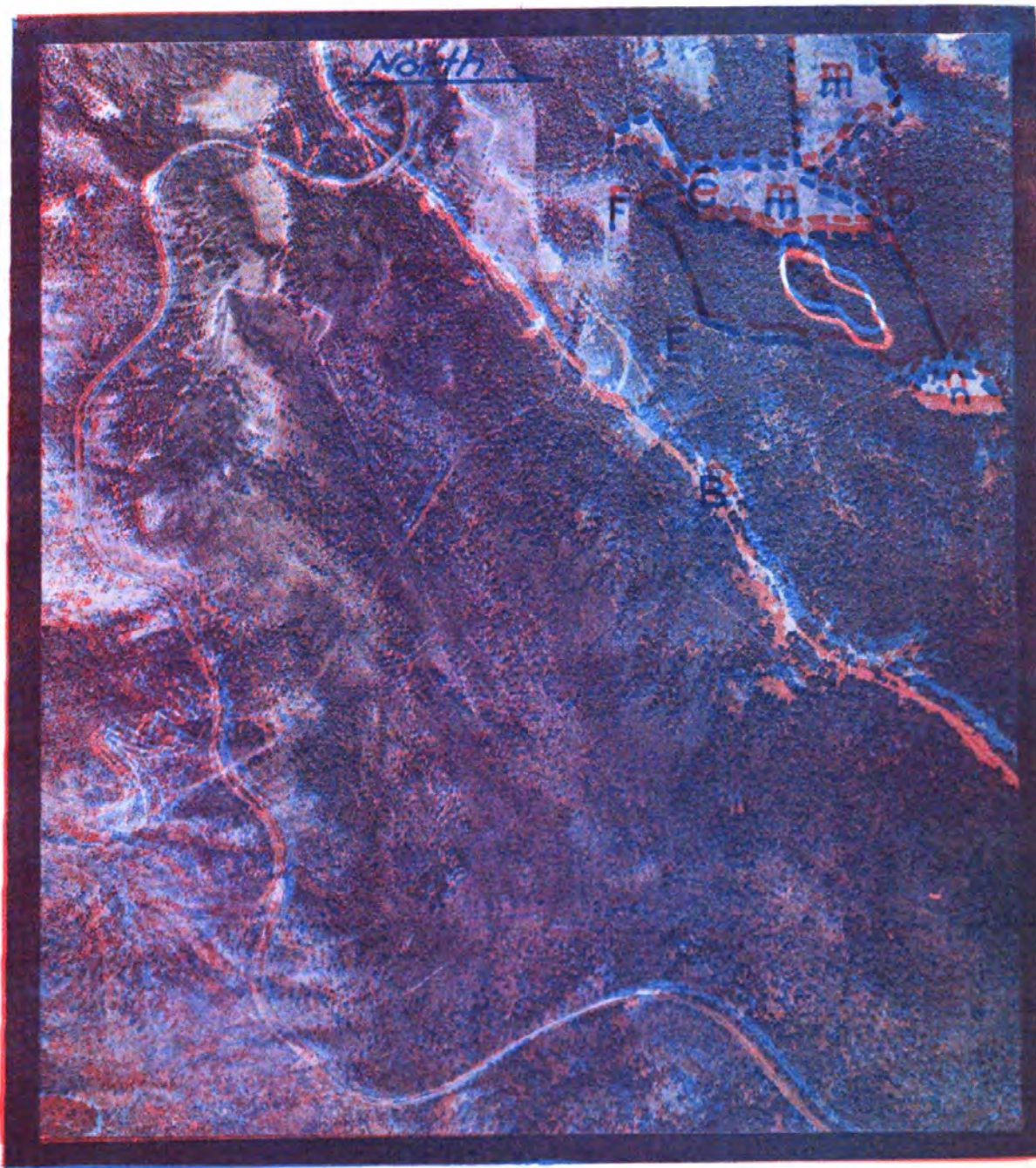
1. *Possibilities:*

- a. Direct attack on fire S. through ponderosa pine area.
- b. Using cultivated land as west line, thence up power line D-A northeast to flat at A on north side and on southeast from flat at A down telephone line right-of-way A-B to State highway, using roads and openings on northwest side of highway and old road to C.
- c. Same as (b) to flat A and then follow old trail from flat south and southwest down ridge to E & F to old road between F & C which will be used back to cultivated land at C.

2. *Decision:*

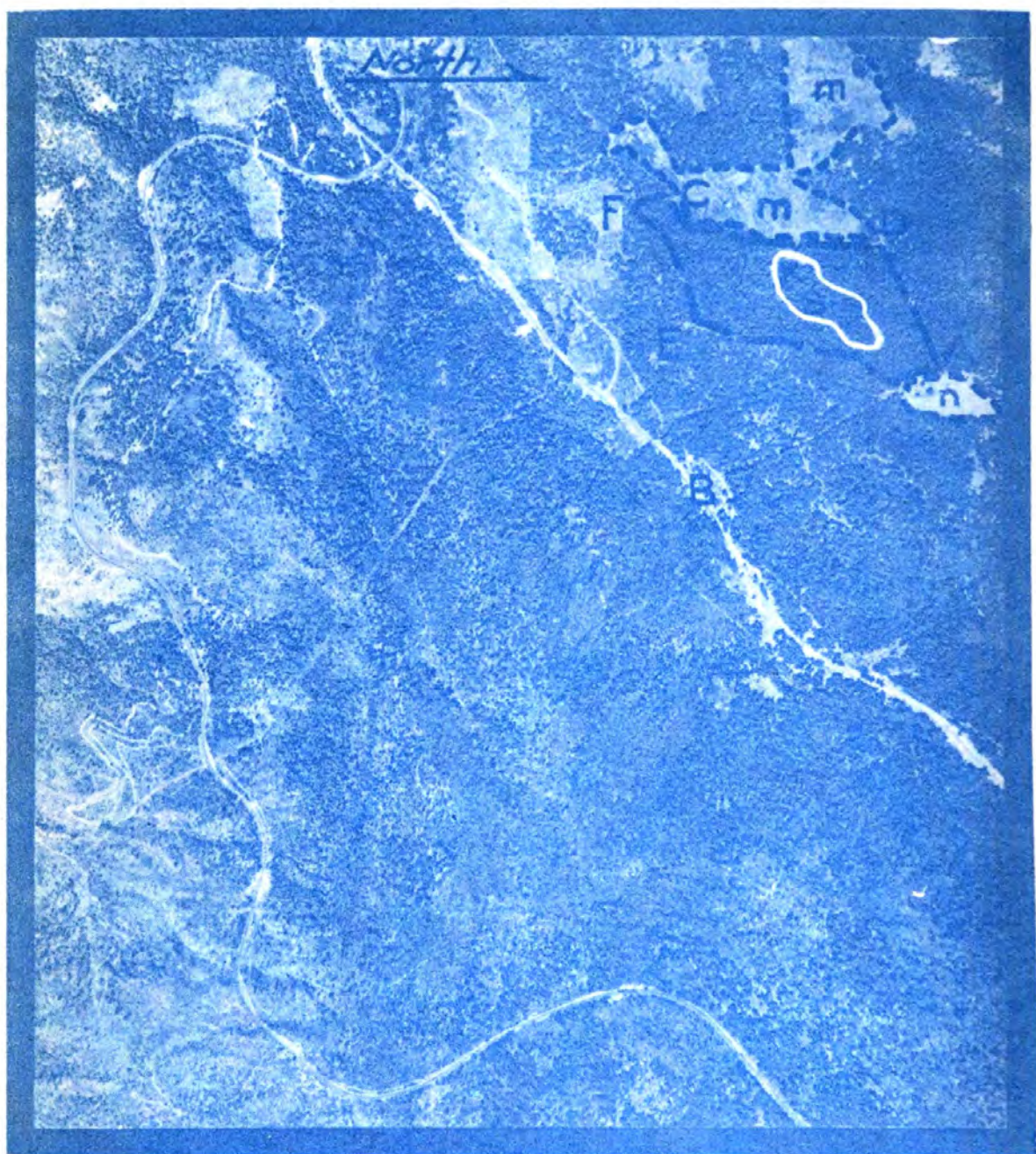
Use plan (c) which can be handled with the manpower available within time limit. Lines used are already cleared and can be back-fired and held with relative ease.

If (a) is used, with the current rate of spread, men would not be able to complete line for the 90 ch. perimeter already covered and the 45 ch. which would be added while they are working. (8 men per 10 ch. of line construction per hour.) (See Line Construction Table.) The fire would probably slope over the ridge on both sides of the ravine with consequent undercut line, rolling material, and loss of line with increased acreage burned.



Scale $1'' = 1.5 \text{ m}$

Fig. 15



Scale $1'' = 1.5 \text{ mi.}$

Fig. 15

LINE LOCATION

DECIDING ON RIDGE OR GULCH, DEPENDING UPON CHARACTER OF GROUND AND ATTACK FORCES AVAILABLE

Problem 5

USE FIGURE 16

Conditions

Region: North Coast Range, Zone 1.

Time of year: September.

Time of day when planning begins: 6:00 P.M.

Size of fire when this planning begins: 100 ac.

Perimeter at time planning begins: 200 ch.

History of fire: Fire broke away from initial attack and made a run of around 100 ac. It was still down in the main canyon bottom below the main ridge surrounding the drainage.

Weather: Normal for the period with no material change predicted in the near future. Prediction is for some rise in humidity and fuel moisture at night, slowing down rate of spread, but still permitting backfiring until about 2:00 A.M.

Elevation: 2,500' to 3,200'.

Topography: Ridges of gentle to moderate slopes, broken up by two deep canyons.

Rate of spread types: Chamise at lower elevations leading up to timber on the ridge tops. Ridge E-K-D-F open mature timber; ridges E-C-A and A-B-F heavy brush.

Resistance to line construction types: Canyon bottom A-H-D very rocky. Lower slopes into canyon rocky and very steep. Both canyon and lower slopes very poorly adapted to either hand or tractor line. Ridges A-C and A-B over 55% slope. Ridge C-E-K-D-F only medium difficult; can do 24 ch. per hour for heavy tractors. (See Tractor Production Table.)

Manpower available: 75-man crew on job at 6:00 P.M.

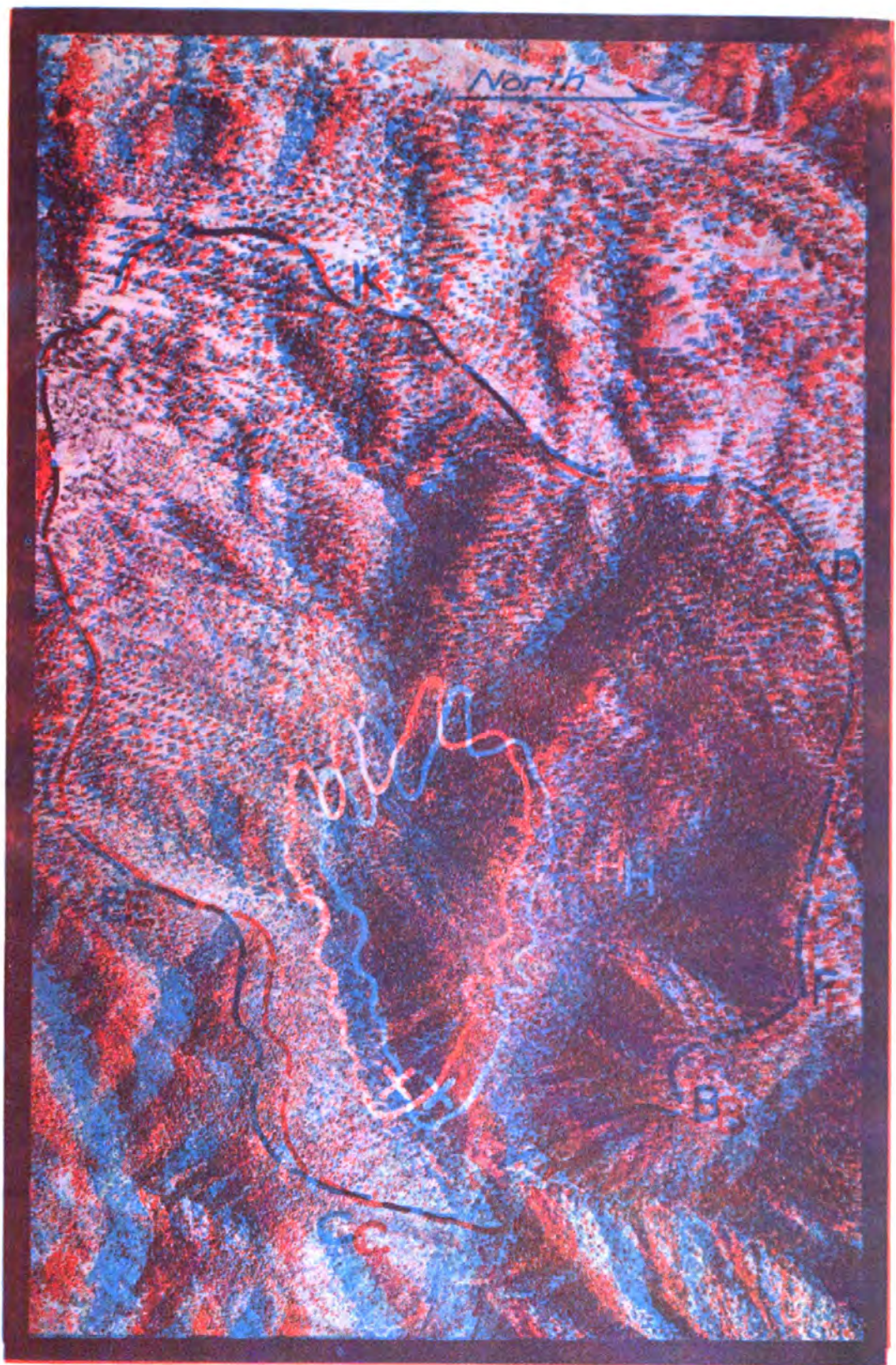
Equipment available: Two RD-7 tractors were on the job at K for line construction at 6:00 P.M.

Solution Required

Where should the control lines be located in view of the character of the country and the facilities available?

Acceptable Solution

Locate lines on ridge top B-D-K-E-C crossing canyon from C to A to B. Very doubtful if available manpower could construct and hold entire line in canyon A-H-D or on lower slopes. Ridge safest stand. The two trailbuilders would be able by 2:00 A.M. to construct the 340 ch. of ridge line C-E-K-D-F by working steadily at the rate of 24 ch. per hour each. This line could be backfired out progressively during the night and held with the available manpower. The 75 ch. hand-made line C-A-B-F could be completed also within time limits and fired out. While the area could have been reduced had it been possible to build the line in the canyons, the character of the country and the location of the fire made this impracticable.



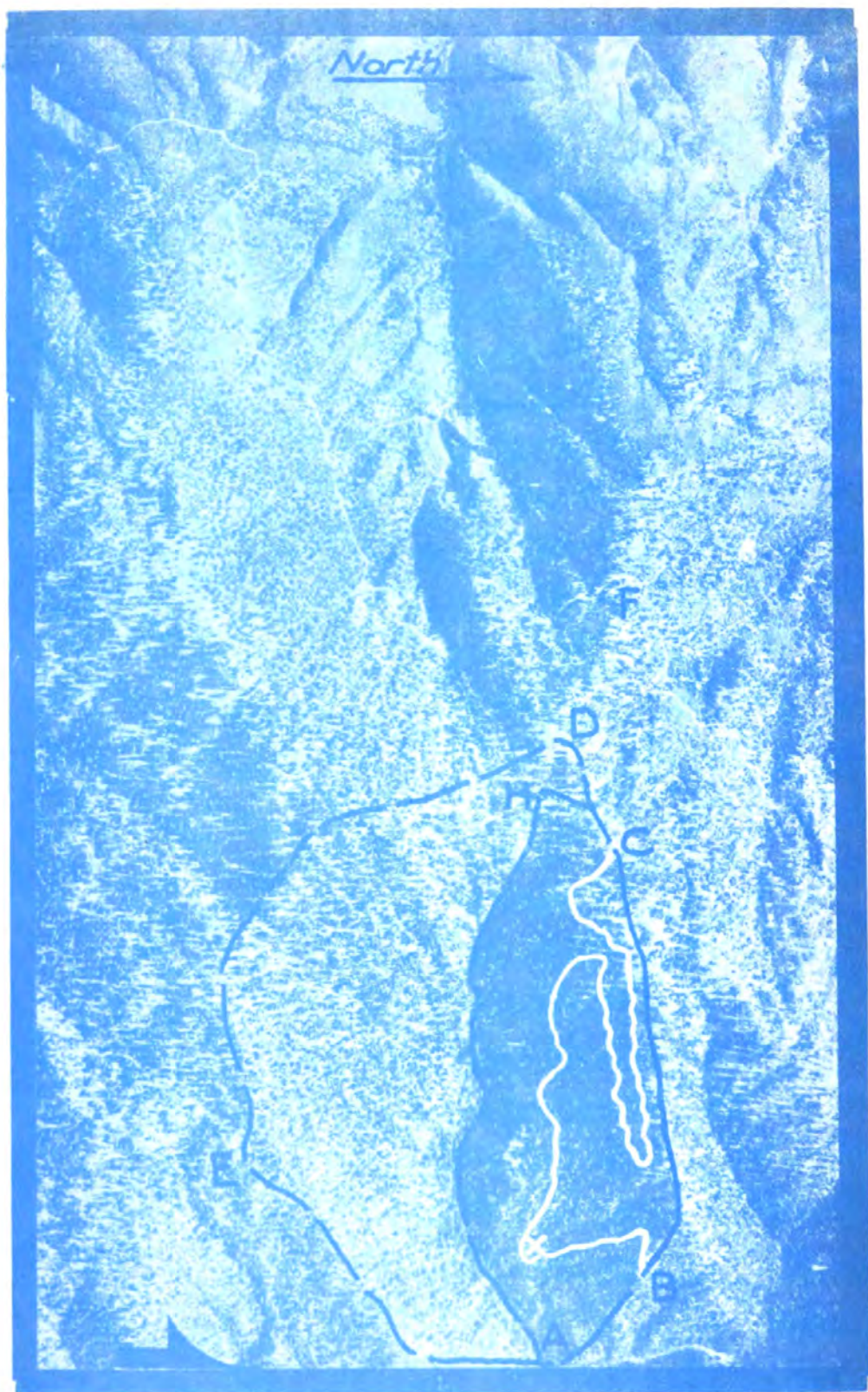
Scale 3" = 1 mi.

Fig. 16



Scale 3" = 1 mi.

Fig. 16



Scale 3" = 1 mi.

Fig. 17



Scale $3'' = 1 \text{ mi.}$

Fig. 17

LINE LOCATION

SELECTION OF RIDGE OR GULCH FOR BACKFIRE LINE

Problem 6

USE FIGURE 17

Conditions

Region: Southern California, Zone 1.

Time of year: August.

Time of day when planning begins: 4:00 P.M.

Size of fire when planning for final control action begins: 35 ac. (eliminating increase in area incident to backfire).

Perimeter of fire when planning for final control action begins: 90 ch. (eliminating perimeter increase incident to backfire).

History: Fire started 3:00 P.M. Its advance to north has been controlled along ridge B-C with backfire. Fire creeping southward to bottom of canyon A-D.

Weather: Wind, 6 mi. per hour with direction up canyon (A-D); relative humidity, 15%; fuel moisture, 4%. Wind predicted to pick up considerably by 6:00 P.M. other factors remaining the same.

Elevation: 2,800' to 4,000' from canyon, point A, to ridge, point D.

Topography: Sides of canyon steep, 40% slope average; canyon bottom, point A to point D, moderate slope, 20% to 25%.

Rate of spread type: Heavy brush, occasional punky oak snags, north side of canyon, A-D. Scattered brush, heavy cover of grass south of canyon, A-D.

Manpower available: All additional men needed can be on fire line by 4:30 P.M.

Roads and trails: Road, point F.

Values: Uniform.

Solution Required

1. Should bottom of gulch DA be used as fire line, or top of ridge D-E-A?

Acceptable Solution

There are two possible solutions to problem:

1. Commencing at point C, work up ridge, dropping into canyon at point H, thence down canyon to point A, completing meanwhile line B-A, timing the operations to meet at point A. Due to the predicted increase in wind velocity at 6:00 P.M., it will be necessary to backfire this line as construction moves forward to complete it before the change occurs.

2. Commencing at point C, work along ridge to point D, thence down ridge to points E and A, completing meanwhile line B-A, timing the operation to meet at point A. These lines must also be backfired as line construction is carried forward.

The fire boss selects solution No. 2, since there is less chance of the fire escaping the control lines, using this location for the control line along this sector, the reason being that a backfire along the bottom of a deep, narrow canyon generally results in spotting to the opposite side. This is especially apt to occur when the side to be burned out is covered with dense brush and the opposite side is covered with a dense growth of dry grass, wild oats, or similar highly ignitable material.

The possibility of holding the canyon is much greater if the cover on the slope to be backfired is not so heavy and if that on the opposite slope is not of a flashy character.

LINE LOCATION

EFFECT OF CONSIDERATION OF VALUES ON LINE LOCATION

Problem 7

USE FIGURE 18

Conditions

Region: West side slope, Zone 1.

Time of year: Mid-August.

Time of day when planning begins: 3:00 P.M.

Size of fire when planning begins: 210 ch.

Perimeter of fire when planning begins: 230 ch.

History of fire: Fire started at x has been burning for 6 hours outside of National Forest protection boundary, having escaped from State forces. Has forked up two ravines.

Weather, current: W. wind and up draws; velocity 8 mi. per hour; relative humidity, 15%; fuel moisture, 4%.

Predicted: For night, SE. wind, 1 mi. per hour; relative humidity, 30%; fuel moisture, 5%.

Elevation: 1,400' to 2,500'.

Topography: Canyon slope with several ravines running NW.-SE. to fire break.

Rate of spread types: Grass, medium brush, oak, buckeye to 2,000' elevation, up to but not including the Ponderosa Way. Mature stand ponderosa pine, some reproduction, needles, occasional snags, stumps and logs south and east of Ponderosa Way.

Barriers: Ponderosa Way fire break A-B. Road B-F.

Water available: River to north of fire area. Occasional springs and storage tanks along road in vicinity of Ponderosa Way.

Manpower available: All that are required for the job have been mobilized and are at the firebreak.

Equipment available: 300-gallon tank truck, special flame-thrower equipment, hand tools as necessary.

Roads and trails: Roads tapping firebreak at various points; also along firebreak from B-F.

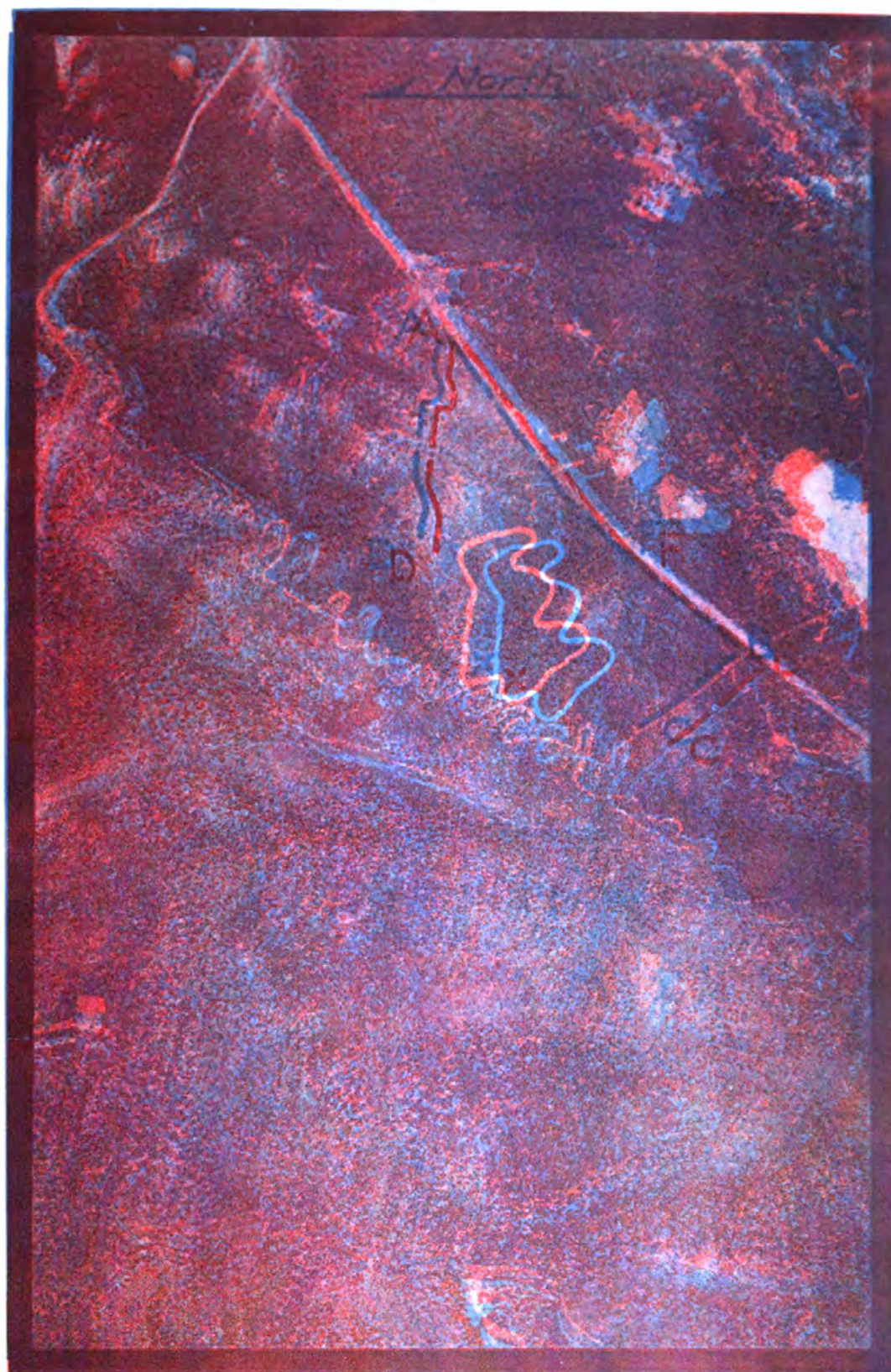
Values: Low value country NW. of firebreak. Good stands mature ponderosa pine southeast of firebreak.

Solution Required

1. What basic principle does the location of the Ponderosa Way at this point illustrate clearly?
2. Where would side lines be located to protect the control of fire's head, assuming that only the head rather than entire fire is considered?

Acceptable Solution

1. Ponderosa Way firebreak location indicates it is placed so as to separate timbered from non- or sparsely timbered country.
2. After controlling the head of the fire along the Ponderosa Way, plan on taking side lines and backfiring from A-D along trail and along the B-C telephone lines clearing sufficiently far so that main fire will not outflank backfire.
3. Loss of material area NW. of Ponderosa Way not serious due to very low values involved and the obtaining of assured protection of timbered, relatively high-value area NE. of Ponderosa Way at minimum cost.



Scale 1" = 1 mi.

Fig. 18



Scale 1" = 1 mi.

Fig. 18



Fig. 19

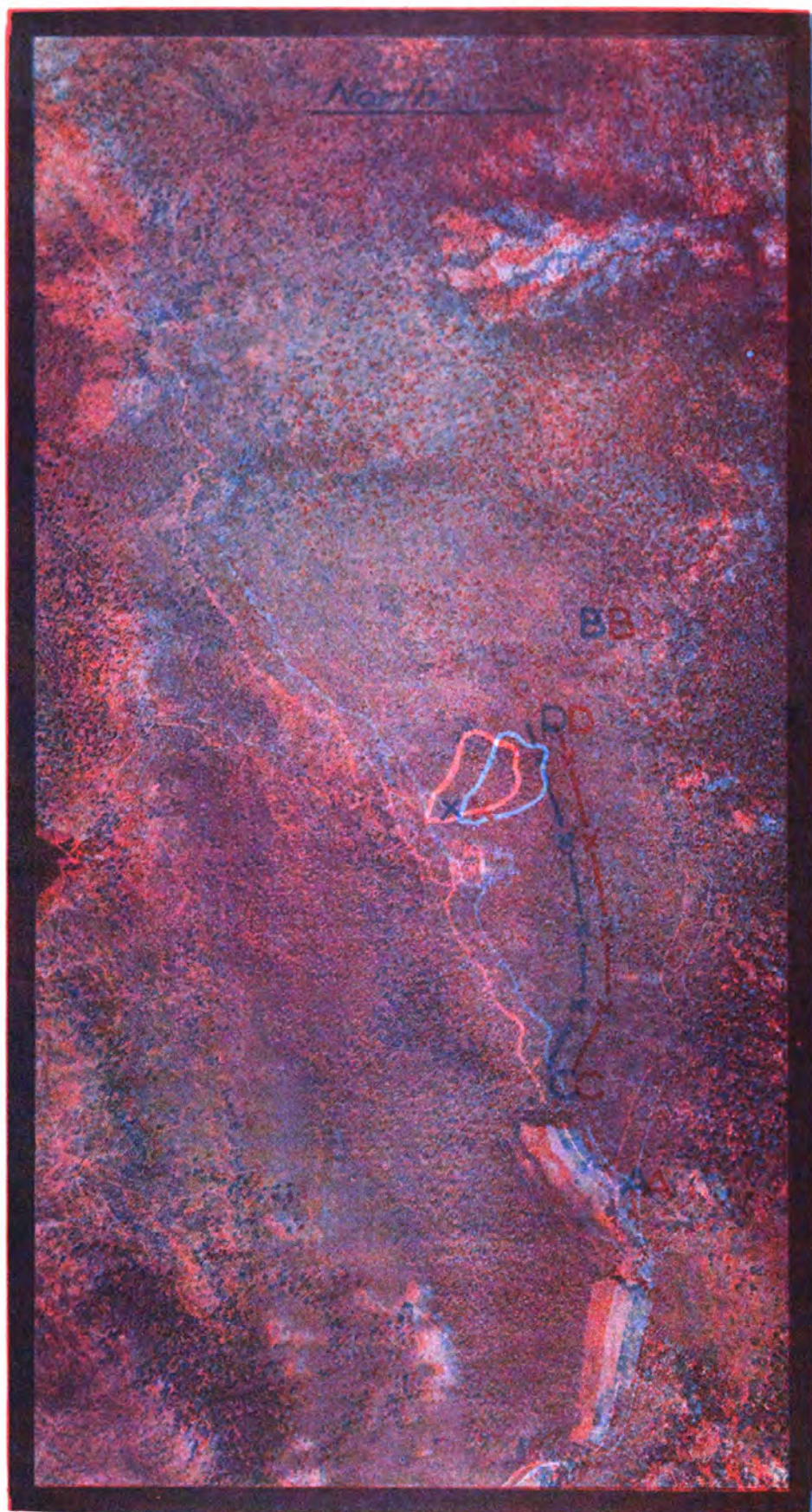


Fig. 19

LINE LOCATION

SAFETY OF MEN AS FACTOR IN LINE LOCATION

Problem 8

USE FIGURE 19

Conditions

Region: Southern California, Zone 1.

Time of year: August.

Time of day when planning begins: Late afternoon.

Size of fire when planning begins: 5 ac.

Perimeter when planning begins: 38 ch.

History to date: District Ranger and crew of 20 men arrive at the fire to find it burning quite strongly well up a brush-covered slope. About 50 yards above the fire the Ranger knows there is a crooked, narrow, poorly brushed-out trail C-D that leads into a spring. The main ridge 20 ch. above has trail A-B well cleared out on it.

Current weather: Normal for this time of year.

Elevation: 3,400' to 4,000'.

Topography: Mountain side with numerous shallow draws.

Rate of spread types: Chaparral 6' to 8' high south of trail A-B.

Solution Required

Looking at the question of attack to control the head of the fire primarily from the angle of safety of the men, should the Ranger plan to make his attack on the trail?

Acceptable Solution

It would be highly hazardous to put men in front of this rapidly spreading fire in the dense brush on the narrow and crooked trail. The men could not be withdrawn to safety if the fire took its normal course and swept over the trail before this could be opened up to safe width. Either start from heel and work up both sides or backfire from relatively safe fire line along ridge to the north (A-B).

LINE LOCATION

KEEPING FIRE OUT OF HIGHER HAZARD TYPES

Problem 9

USE FIGURE 20

Conditions

Region: East side, Zone 1.

Time of year: August.

Time of day when planning begins: 2:00 P.M.

Size of fire when planning begins: 15 ac.

Perimeter of fire when planning begins: 42 ch.

History to date: Two guards got to this fire which was in cutover land at 1:30 P.M. (20 minutes after it was reported), but were able to do little with it. The Ranger and 25 men arrived on the scene at 2:00 P.M. About a quarter of a mile to the west of the head of the fire he knew there was an area of ponderosa pine snags (area a) which had been killed by insects 3 years before.

Weather: Normal burning conditions with no changes impending. Wind east.

Elevation: 6,000'.

Topography: Rolling, with gradual rise to north.

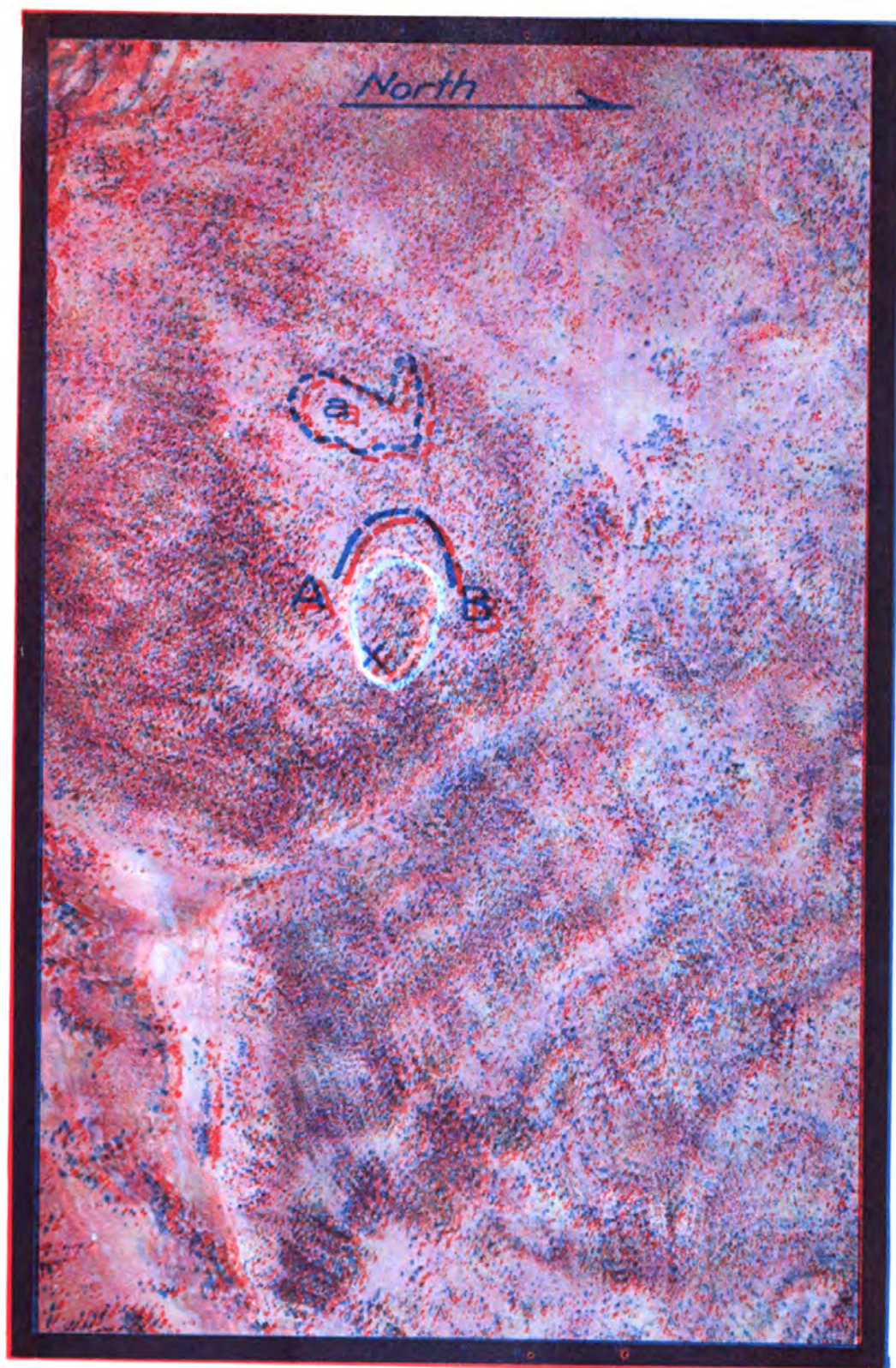
Rate of spread types: Cut-over ponderosa pine—brush piled and burned. Some bug-killed snags in residual stand.

Solution Required

What would be the major point to consider in deciding fire-line locations and priorities?

Acceptable Solution

The most troublesome and difficult element to handle is the snag field (a) from which the fire should be kept if at all possible. Since in this type fire spotting in advance of the fire area proper is commonly a source of trouble, the farther away the fire can be kept from the snag area the less chance there will be that some of these will be ignited. Give first priority to stopping westward movement of fire by immediate location and construction of fire line A-B.



Scale 3'' = 1 mi.

Fig. 20



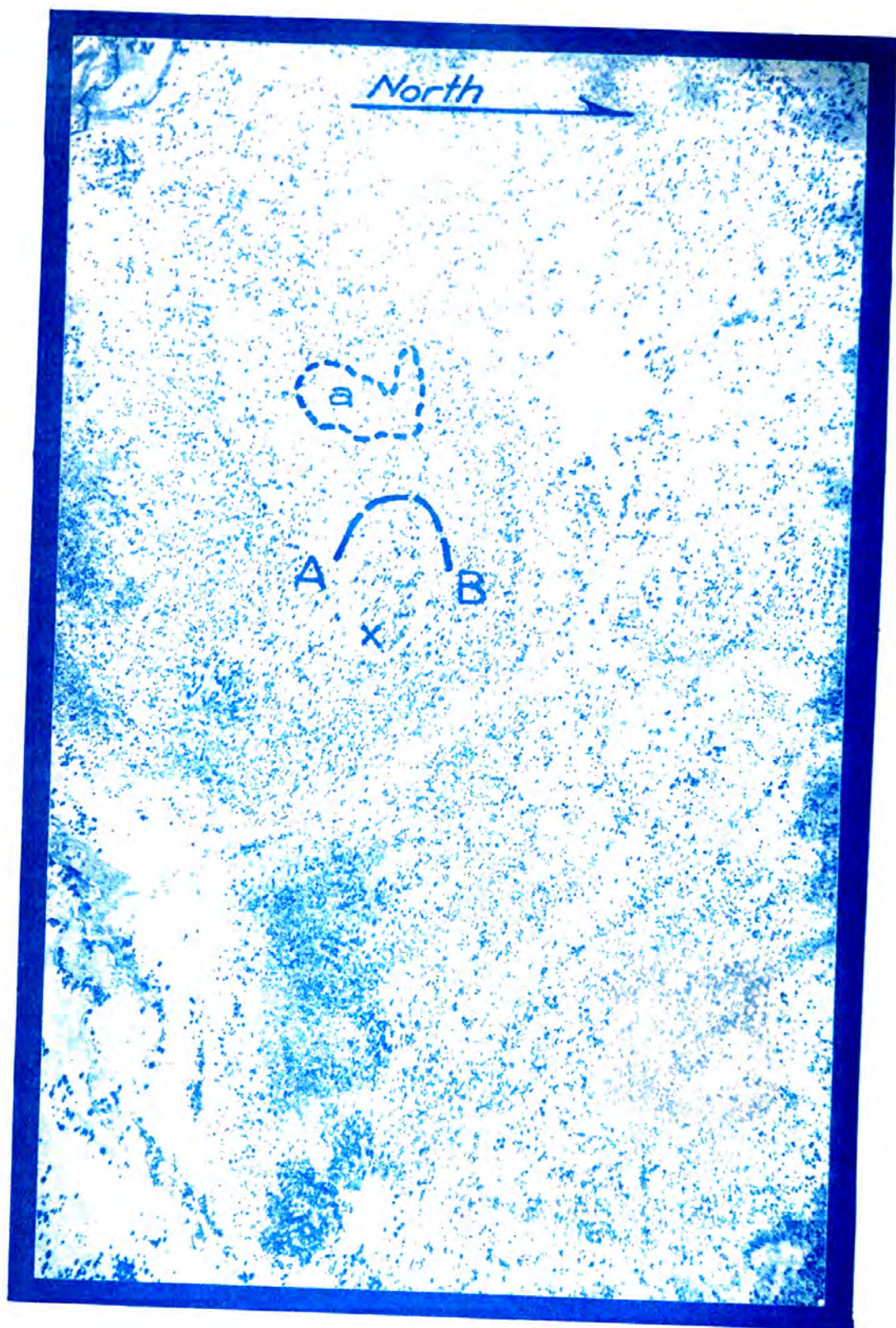
Scale 3" = 1 mi.

Fig. 20



Fig. 21

Scale $1'' = 1$



Scale 3" = 1 mi.

Fig. 20



Fig. 21

Scale 1" = 1 mi

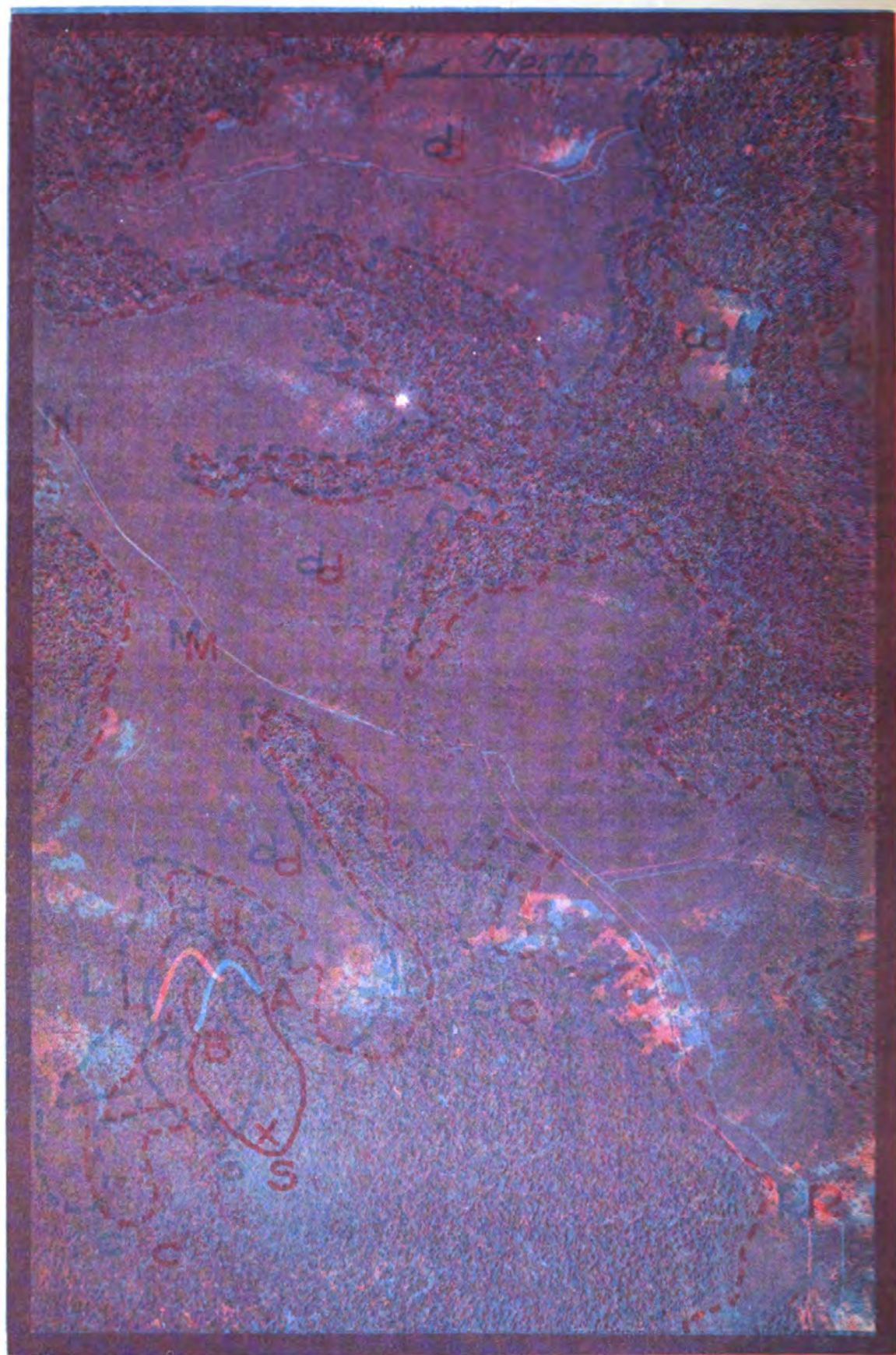


Fig. 21

LINE LOCATION

EFFECT OF CONSIDERATION OF EXTERIOR HAZARDS IN LINE LOCATION

Problem 10

USE FIGURE 21

Conditions

Region: West side, Zone 1.

Time of year: Late August.

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: 230 ac.

Perimeter of fire when planning begins: 210 ch.

History to date: Fire started at (x). Flank attack by adequate crews resulted in completed control lines from S to A and S to B by 5:00 P.M.

Weather, Current: W. wind, 4 mi. per hour in open; relative humidity, 18%; fuel moisture, 4%.

Predicted: For night 6:00 P.M. on, W. wind, 1 mi. per hour; relative humidity, 25%; fuel moisture, 5%.

Elevation: 5,100' at B to 5,400' at top of ridge.

Topography: Even slope north and east to top of brush-covered ridge. Ravine on north side of fire near B.

Rate of spread types: Mature ponderosa pine with light brush understory, few logs and snags (area c). Dense manzanita brush field (area d).

Manpower available: Sufficient to handle job.

Equipment available: Hand tools, backfiring equipment, back pack pumps only in quantities needed.

Roads: From L to M, N to R.

Solution Required

Where would line be located at head of fire to keep fire from entering areas of greater hazard?

Acceptable Solution

Locate line in the timber from A to H and from B to H to keep fire from getting into dense brush which has faster rate of spread and much higher resistance to line construction. It was impossible to do the actual construction work on the head until the fire had slowed down, though work on line S-A had been pushed faster than line S-B with the wind direction and hazards ahead in mind.

LINE LOCATION

LOCATION OF LINE TO PREVENT FIRE FROM ENTERING AN AREA
WHERE THE RESISTANCE TO LINE CONSTRUCTION AND
RATES OF SPREAD ARE VERY HIGH

Problem 11

USE FIGURE 22

Conditions

Region: West side, Zone 1.

Time of year: Mid-August.

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: 100 ac.

Perimeter of fire when planning begins: 145 ch.

History to date: Fire started at point (x) at 3:00 P.M. By 5:00 P.M. fire had attained area shown by solid line.

Weather, current: NW. wind, 8 mi. per hour; relative humidity, 15%; fuel moisture, 4%. No change predicted.

Elevation: Approximately 4,500'.

Topography: Slopes gentle. No deep canyons or sharp ridges.

Rate of spread types: Area (a) manzanita—twice as rapid a spread type as ponderosa pine (c), but with same rate as grass (d).
Area (b) barren.

Resistance to line construction types:

Area (a) .7 chains per man hour.

Area (c) 4.6 chains per man hour.

Area (d) 4.0 chains per man hour.

Barriers: Area (b) placer diggings—bare soil.

Water available: Water for tanker at point (A).

Manpower available: 65 men at point A—fire camp.

Equipment available: All necessary.

Roads: A to B to C.

Values: Surrounding high values of mature timber.

Solution Required

Where should control lines be located with due regard to keeping fire out of types where greater difficulties of line construction are to be found?

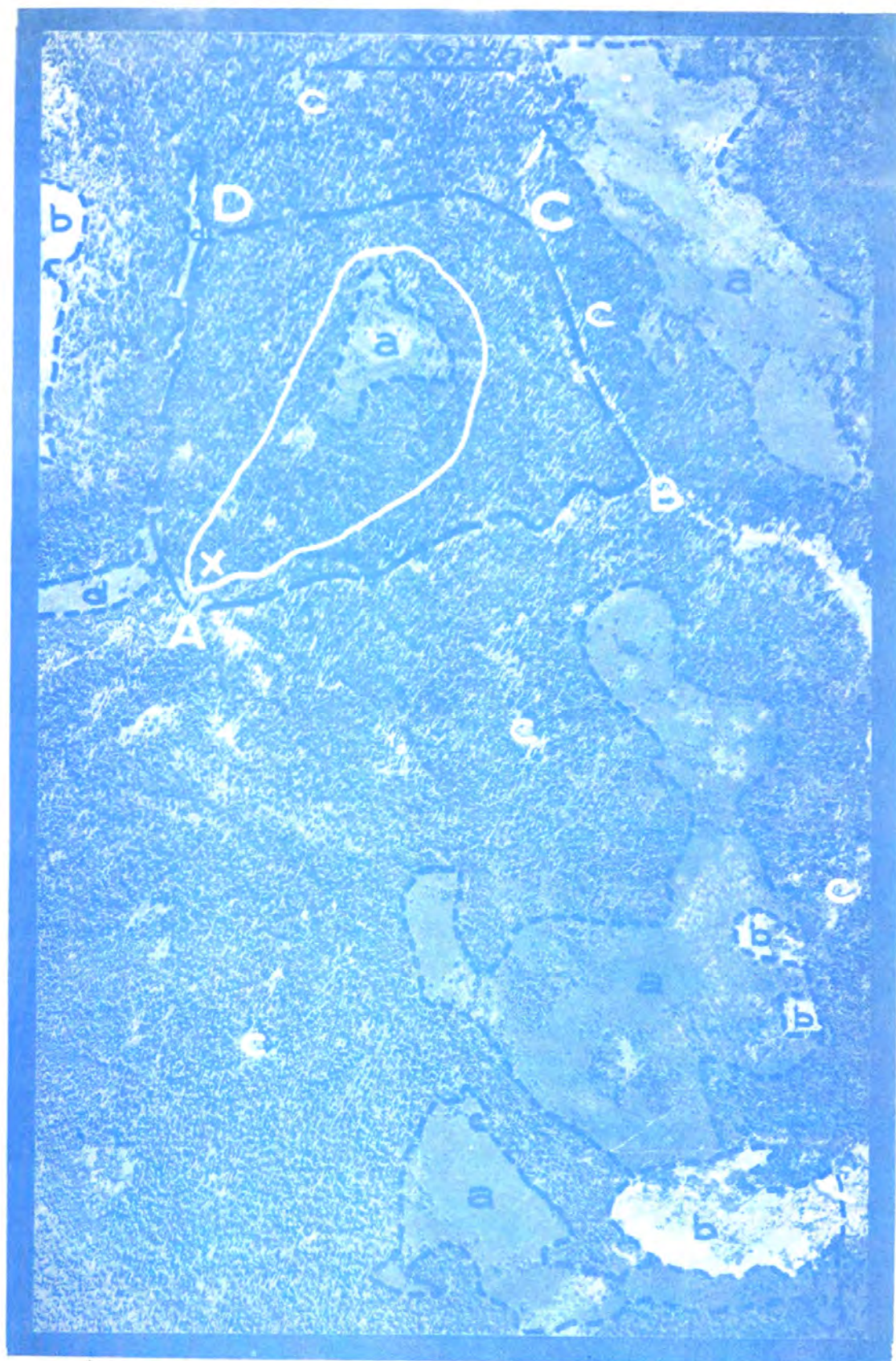


Fig. 22

Scale 3" = 1 mi

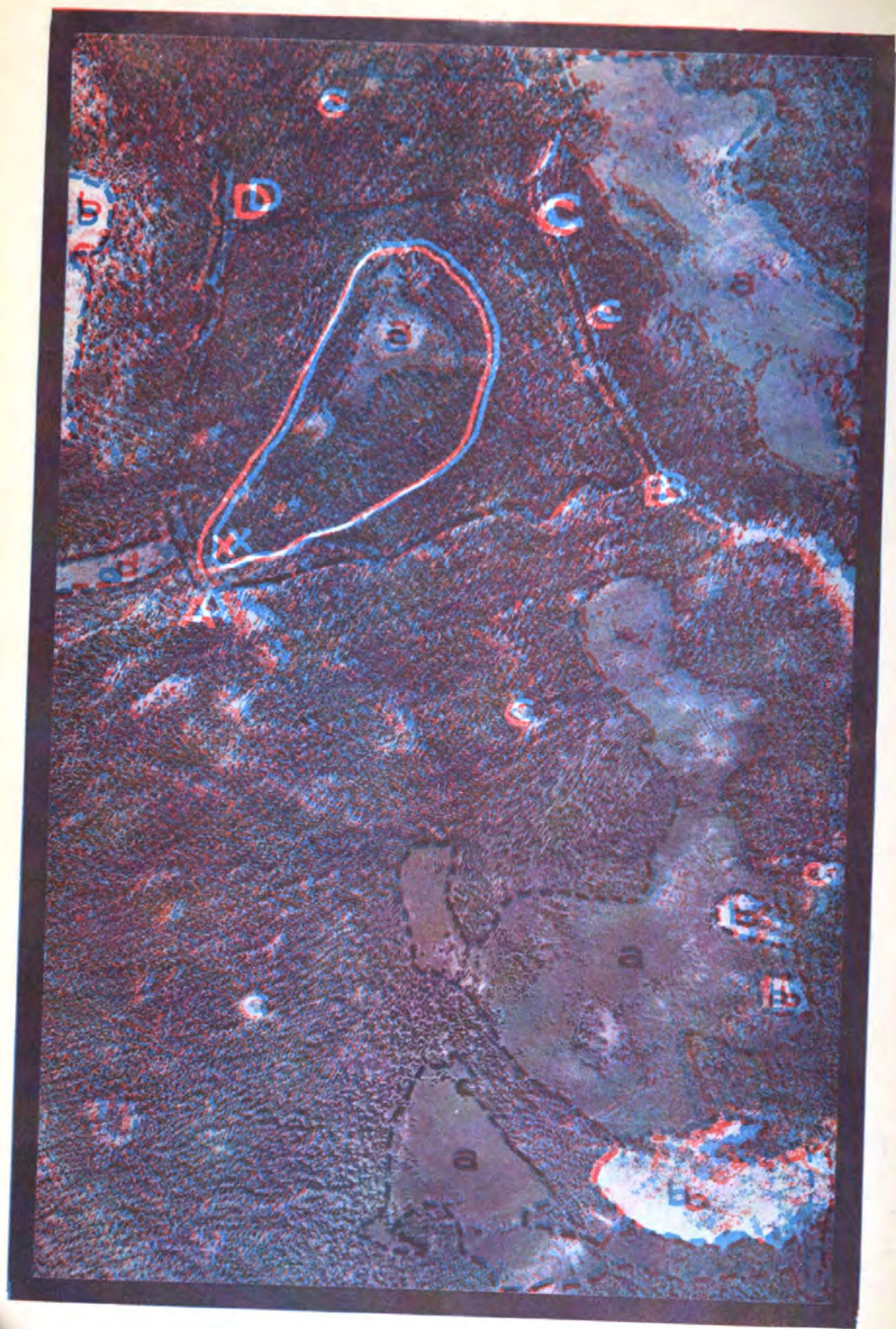


Fig. 22

Scale 3" = 1 mi

Acceptable Solution

Locate lines as follows: A-B, B-C, C-D, and D-A.

Greatest threat is that fire will enter brushfield (a) south of line B-C. Only location which is sufficiently ahead of the fire on which limited manpower available can hope to check it is on the road B-C, and extension of the line through timber C-D.

Line A-B is of next importance to prevent possible spread into brushfield to the west. Line A-D can be left to the last as its immediate construction is the least important.

Supplemental

Calculations entering into solution.

a. *Present perimeter*: 145 ch.

b. *Forward progress*: 54 ch. in 2 hrs or 27 ch. per hour on uphill spread.

c. *Distance of head of fire to road B-C*: 13 ch. in advance of head of fire or approximately 1 hour of spread due to fire slowing down 50% when burning down hill.

d. *Final area*: 270 ac.

Calculation of manpower requirements, distances, and character of work.

Road line—A-B-C. 107 ch.

Backfire—10 men.

Hold—1 man per 10 ch. = 11 men.

Timber line—C-D and portion of A-D. 74 ch.—construct, backfire, hold.

Construction 74 ch. @ 4.6 ch. per man hour = 16 men.

Backfire—3 men.

Hold—8 men.

Grass line—Portion A-D, 34 ch.—construct, backfire, hold.

Construction 34 ch. @ 4 ch. per man hour—9 men.

Backfire—2 men.

Hold—1 man.

Total: 60 fire fighters to complete initial control in *one* hour.

LINE LOCATION

SELECTION OF LOCATION AS INFLUENCED BY AVAILABILITY OF WATER

Problem 12

Conditions

Region: East side (lava bed), Zone 2.

Time of year: Early September.

Time of day when planning begins: 3:00 P.M.

Size of fire when planning begins: 1 ac.

Perimeter of fire when planning begins: 15 ch.

History of fire to date: Holdover lightning fire has crept around in deep crevices of bed of lava and has flared up occasionally in manzanita thickets.

Weather, current: S. wind, 4 mi. per hour; relative humidity, 20%; fuel moisture, 4%.

Elevation: 4,200'.

Topography: Level lava bed roughly 30 ac. in size in an otherwise unbroken ponderosa pine forest.

Rate of spread types: Lava bed, moderate cover manzanita, some ponderosa pine reproduction, occasional snags, in clumps. Old duff and litter in cracks between lava boulders. No dirt available immediately adjacent to fire. Adjacent ponderosa pine on good soil.

Water available: 20,000-gallon water storage tank 5 mi. from fire.

Manpower available: Suppression squad 5 men and guard dispatched to fire. 5 additional men available at Ranger Station 1 hour from fire.

Equipment available: One 300-gallon tanker with the suppression squad and a stakeside truck with 500-gallon portable tank and extra hose at Ranger Station.

Roads and trails: Truck trail runs within $\frac{1}{8}$ mi. of fire.

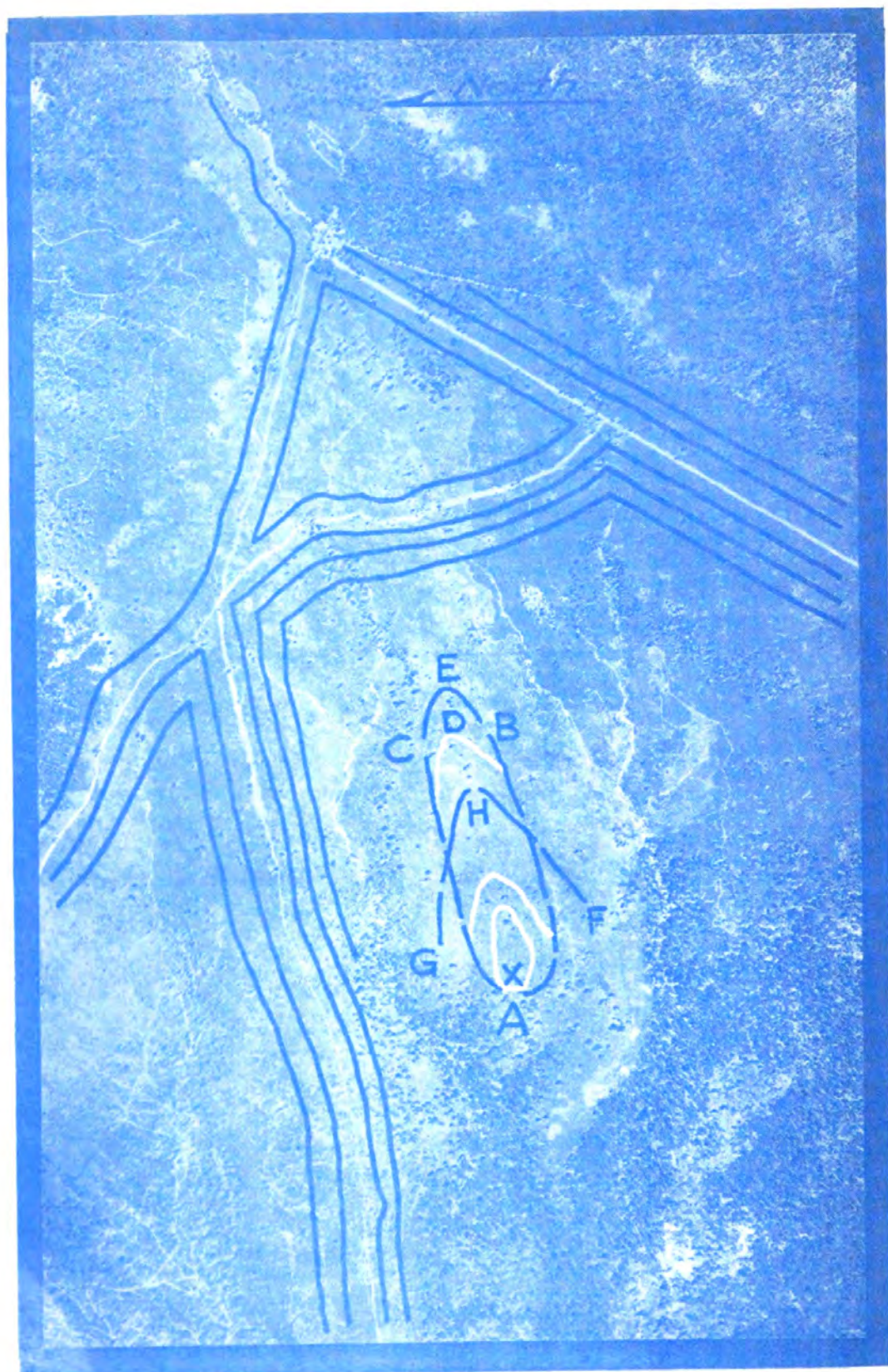
Solution Required

Where would control line be located?

Acceptable Solution

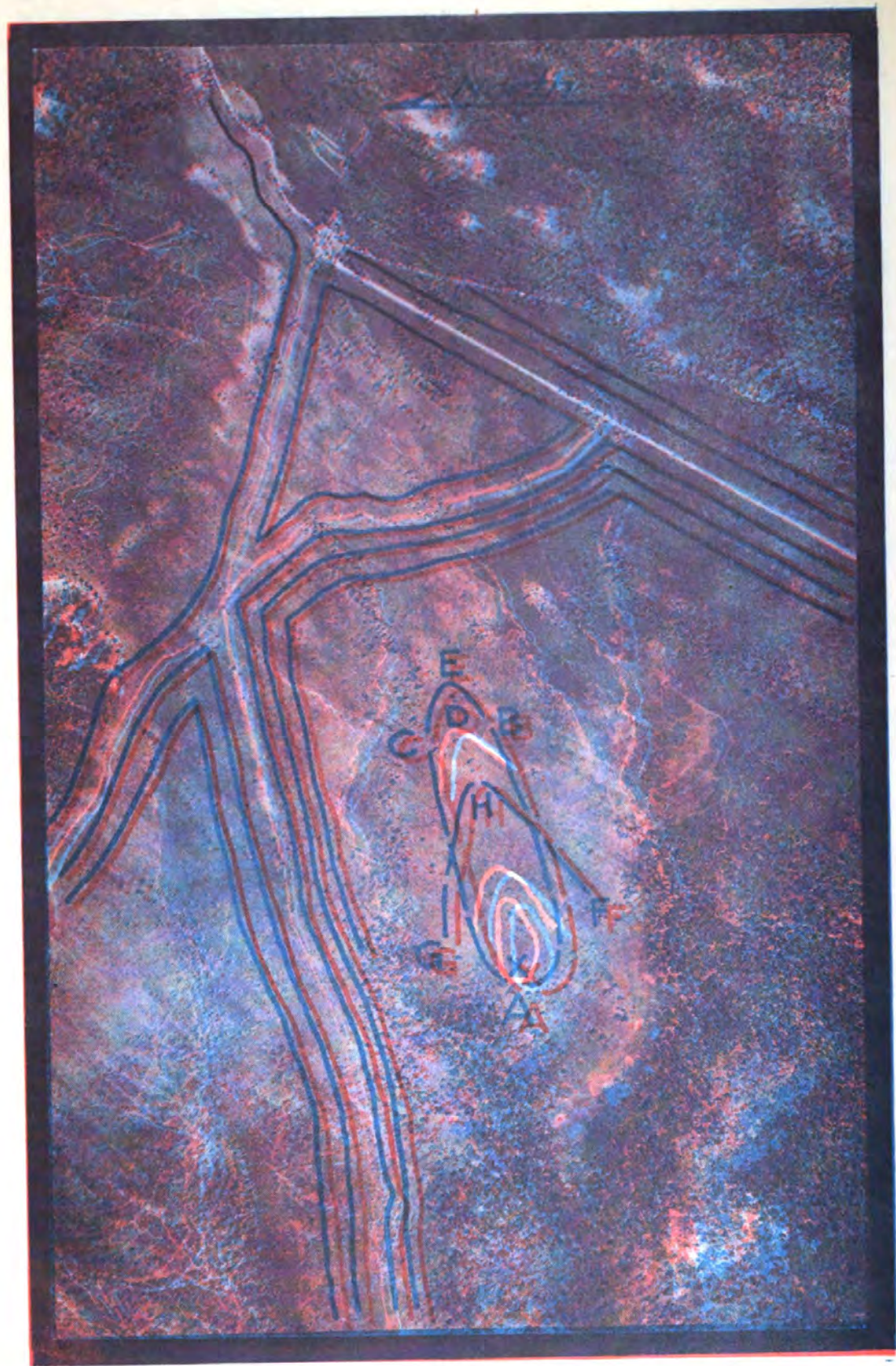
Locate line as close to fire edge as possible because fire can be extinguished with water in an area where adequate hand line cannot be built.

Other alternative would be to drop back and build line in the timber which could be backfired out and held. Objection to this is unnecessary enlargement of burned-over area.



Scale 3" = 1 mi.

Fig. 23



Scale 3" = 1 mi.

Fig. 23

LINE LOCATION

LOCATION OF TRACTOR LINE IN SOLID DENSE BRUSHFIELD

Problem 13

USE FIGURE 23

Conditions

Region: West side, Zone 1.

Time of year: August.

Time of day planning begins: 1:30 P.M.

Size when planning begins: 3 ac.

Perimeter when planning begins: 27 ch. (10 ch. $\times$ 5 ch.).

History: Fire started in dense mixed brushfield at 12:30 P.M.

Weather: SW. wind, 10 mi. per hour; relative humidity, 18%; fuel moisture, 4%. No change except normal nightly fluctuation around 7:00 P.M.

Elevation: 4,500'.

Topography: Gentle, 5-10% slope.

Resistance to line construction types: Medium to heavy manzanita; heavy tractor trailbuilder will construct 20 ch. of line per hour.

Barriers: Roads north and east of fire might be used as barrier, but high value planted roadside strip made burning along roads undesirable.

Manpower available: As needed by 2:00 P.M.

Equipment available: 2 RD-7 trailbuilders can be put on line by 2:00 P.M.

Roads available: Road to north, east and southeast of fire.

Values: Planted roadside strips made it desirable to keep fire from reaching these.

Solution Required

Location of lines for tractor attack.

Acceptable Solution

1. Fire boss figures that with the rapid-spreading fire in medium to heavy brush it is imperative that he secure at least two trailbuilders which can build line at the rate of 24 ch. per hour, as contrasted with manpower production in this type of 1.2 ch. per man hour.
2. When tractors can be put on the line at 2:00 P.M. fire will have a perimeter of 40 ch. (15 ch. long) and acreage of 10 (see map for location).

3. Fire is burning hot, direct head attack is out of the question so fire boss starts both tractors at point A accompanied by necessary crews to hold line and works tractor line up each flank. Each tractor builds 40 ch. of line in 2 hours so will have reached points B-C at 4:00 P.M. This should be approximately even with the head of the fire D because the rate of spread has been progressively reduced as held line is produced along the flanks, thereby preventing side spread. Within another half hour the tractors can work around the head of the fire and complete control along B-E-C.

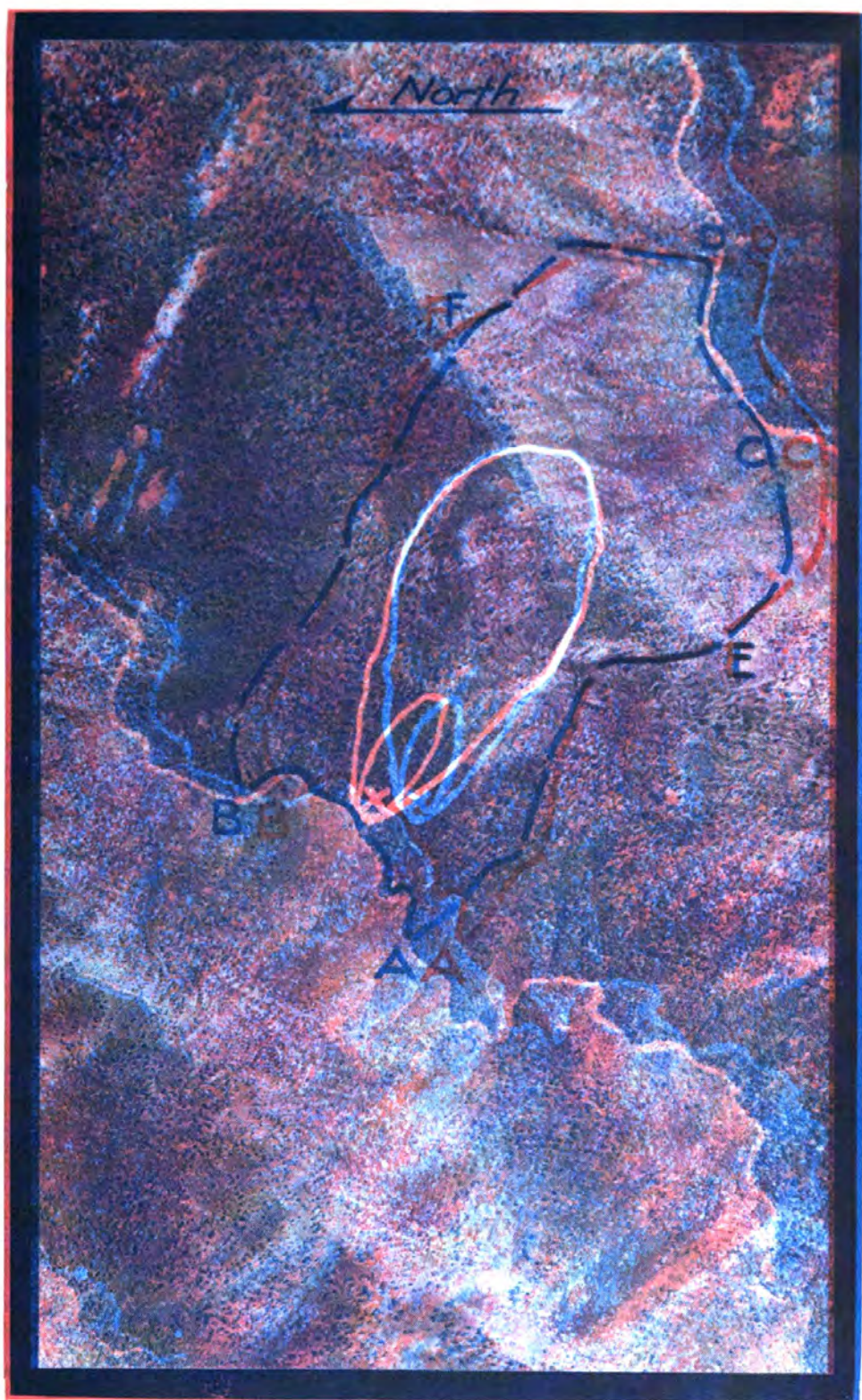
Supplemental

1. If wind conditions remain constant and fire is not spotting at all, rear of fire might be left alone for the time except for hand crews starting flank attack on both sides of the rear with two tractors starting lines at points F and G which are well back of the head of the fire at 2:00 P.M., working lines oblique to the main run of the fire toward point H, which they would reach within approximately 1 hour. Use men on the line to help to knock down small heads of fire that go up against the line. It will not be possible to backfire the line, which should hold with the help of the men because of its oblique relationship to the fire's run.



Scale 3" = 1 mi.

Fig. 24



Scale 3" = 1 mi.

Fig. 24

LINE LOCATION

LOCATION TO AVOID UNDERCUT LINES ON STEEP SLOPES

Problem 14

USE FIGURE 24

Conditions

Region West side, Zone 1.

Time of year: August.

Time of day when planning begins: 2:00 P.M.

Size of fire when planning begins: 7 ac.

Perimeter of fire when planning begins: 45 ch. (15 ch. long).

History: Fire started at 1:00 P.M.

Weather: NW. wind, 8 mi. per hour; relative humidity, 25%; fuel moisture, 5%. Weather will remain constant until 8:00 P.M., when wind will switch to down canyon; velocity 4 mi. per hour on exposed points.

Elevation: 2,000' from bottom of canyon A-B (where fire started) to top of ridge E-F.

Topography: Very steep slopes—on west side near canyon bottom, 85% slope; higher up, 65%. On east side of ridge E-F slope is 85% from top to river D-C.

Rate of spread types: Mixed brush and scattered timber. Spread up the slope has been at the up-slope rate of 15 ch. per hour. After it crosses the ridge fire will slow down to not over 1 ch. axis elongation per hour, exclusive of rolling effect.

Barriers: Rivers at bottom of each slope form good lines of control.

Manpower available: Men to number needed can be put on line by 5:00 P.M.

Trails: One along main ridge through F-E.

Solution Required

1. Under existing conditions where will lines be located to control fire during first burning period?

Acceptable Solution

1. It is approximately 40 ch. from the river B-A to top of ridge E-F. Fire by 5:00 P.M. will have been spreading for 4 hours. It will have reached ridge E-F around 3:45 P.M., using past rate of axis spread as the basis for computing this.

2. By 5:00 P.M. the fire will be well established in the slope below E-F and will have advanced some 10 linear chains down the slope, due to rolling action of burning material.
3. Due to steepness of slope it is obviously extremely dangerous and perhaps impossible to plan to control the fire by an undercut line below it on the slope. Consequently plans are made to select locations along the flanks from F-D and C-E, E-A and B-F to surround the fire, avoiding undercut lines and getting far enough away to permit completion of lines and their backfiring as early in the night as possible.
4. Lines A-B and C-D will have to be cleaned up by backfiring out after flank lines have burned out.

LINE LOCATION

SELECTION OF LINE LOCATION AS INFLUENCED BY FIRE BEHAVIOR

Problem 15

USE FIGURE 25

Conditions

Region: West side, Zone 1.

Time of year: August.

Time of day when planning begins: 3:00 P.M.

Size of fire when planning begins: 200 ac.

Perimeter of fire when planning begins: 240 ch.

History to date: Fire started at (x) at 12:15 P.M.; first attack by 5 men at 12:50 P.M. failed; further attempt to hold rear of fire on slope lost by roll; lower flank working down toward canyon and no immediate threat; at 2:45 P.M. a crew of 30 men from a mine south of the river arrive at point A and are put to work on line A-B to get it tied in before expected down-canyon shift of wind; crew of 40 men arrives at point E on ridge at 3:00 P.M.

Current weather: Up-canyon wind, 10 mi. per hour; relative humidity, 18%; fuel moisture, 4%.

Predicted weather: Shift to down-canyon wind between 5:00 and 6:00 P.M., rising humidity and fuel moisture.

Elevation: 2,300' to 3,200'.

Topography: Moderate along main ridge; steep side slopes into gulches and main canyon.

Rate of spread types: Open brush and timber on main ridges; easy line construction; medium brush and timber on side spurs; medium to heavy brush and scattered timber on side slopes.

Barriers: Main river canyon, A-C-G-K-F.

Water available: In main canyon only.

M manpower available: 35 men line A-B, 40 men point E, 3:00 P.M.

Equipment available: Hand tools only.

Road: Road from point M to point I.

Solution Required

Location of east line.

Acceptable Solution

1. Possibilities :
 - a. Low spur ridge C-E.
 - b. Shallow gulch G-E.
 - c. Higher spur E-J-F.
 - d. Direct attack on head and south flank of fire on side hill.
2. Plans (a) and (b) are not feasible, since fire will in all probability, with present very rapid rate of spread (21 ch. forward spread per hour) which can be expected to continue for 2-3 hours with present up-canyon wind, cross low ridge C-E and shallow gulch G-E, and become established on slope to the east, which has heaviest cover, before a line could be constructed along ridge E-C or canyon G-E. Neither of these locations presents a real topographic barrier to the fire.
3. Plan (d) not feasible because fire too hot and possibility of roll too great to attempt direct attack on the head and south flank.
4. Use plan (c), line E-J-F; it gives time to get line in; backfire can be timed for down-canyon shift of wind; fairly open spur and fast line construction. Manpower available at E will be more than sufficient to handle this line in the time available, which is not the case with relation to the other possibilities. Line E-J-F can be constructed in desired time by 30 men, leaving 10 men to construct line E-B.
5. Don't use J-K; additional area lost small; angle at J would be a source of danger and too close to the area of dense brush on the slope to the west.

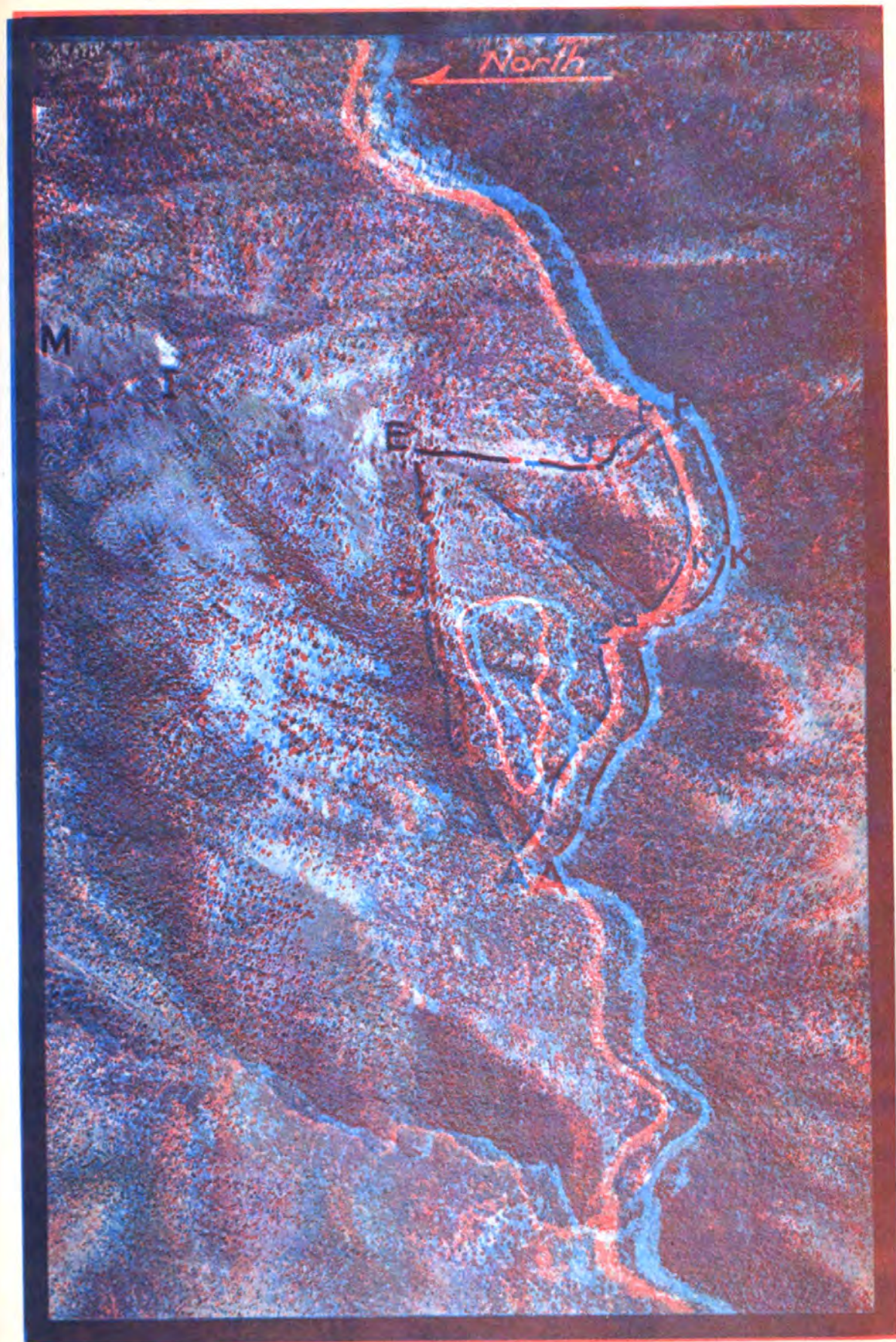


Fig. 25



Fig. 25

Scale 1" = 1 mi



Fig. 26

Scale 3" = 1 mi

North

M

E

F

J

B

K

G

A





Fig. 26

Scale $3'' = 1 \text{ m}$

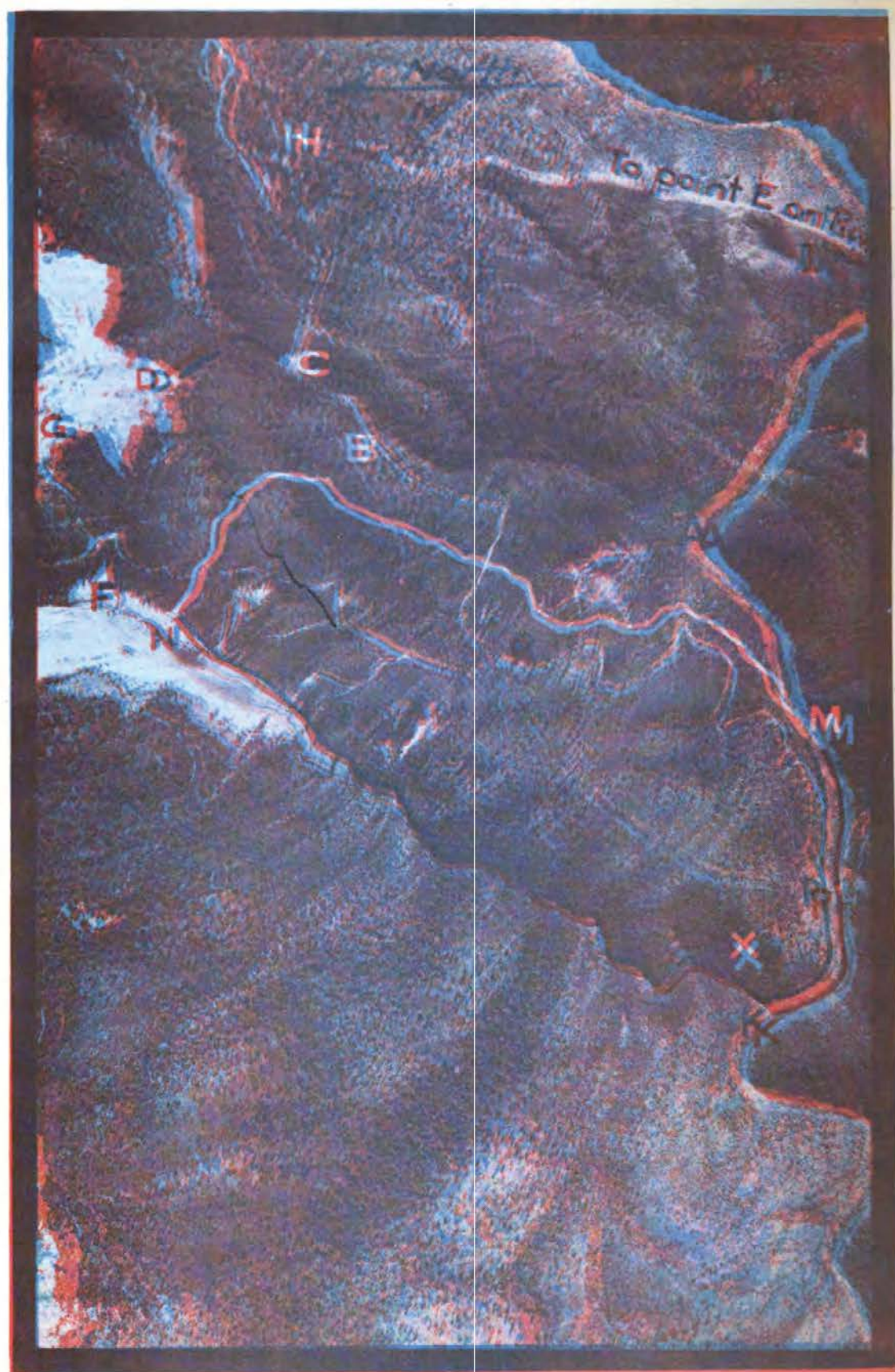


Fig. 26

Scale 3" = 1 mi.

LINE LOCATION

INFLUENCE ON MANPOWER AVAILABLE

Problem 16

USE FIGURE 26

Conditions

Region: West side, Zone 1.

Time of year: September.

Time of day when planning begins: 3:00 P.M.

Size of fire when planning begins: 380 ac.

Perimeter of fire when planning begins: 260 ch.

History to date: Fire started 11:30 A.M. at point (x). Two 10-man crews on fire at 12:15 P.M. One held line on main canyon (M-K) and other on side canyon (K-N) and have kept fire from crossing through, backfiring these lines to keep up with the spread of the fire on its flanks. No work beyond points M and N.

Weather, current: SW. wind up canyon, 8 mi. per hour; relative humidity, 18%; fuel moisture, 4%.

Predicted: Continue same till about 6:00 P.M., then wind shift to down canyon, with rising humidity and fuel moisture.

Elevation: Main canyon 2,000', diggings and ridge top 3,500'.

Topography: Moderate slopes.

Rate of spread types: Mostly medium dense brush and scattered timber, but heavy brush and scattered timber in gulch A-B.

Barriers: Old placer diggings ahead of fire G-D. Canyons N-K-M-A-E. Road H-C-P, R-F; firebreak and road from H-I; firebreak from I-E; gravel wash F-G. (Need attention, however.)

Manpower available: Crew of 30 fresh men arrive at C at 3:00 P.M. Another crew of 10 fresh men reach old diggings near point F at 3:15 P.M. No other men available till late evening.

Equipment available: Hand tools and backfiring torches—no tractors or tankers.

Roads: Roads along H-I, H-C-P, and R-F.

Values: Uniform.

Solution Required

How to control fire with existing manpower.

Acceptable Solution

1. Fire is so close to gulch A-B that only immediately available tractors plus a large crew could be expected to cut line and hold it. If adequate men and tractors had been available, line could have been successfully constructed and fire held in canyon A-B, making use of portions of existing roads.

2. To accomplish control with available forces existing barriers must be used to maximum extent.
 3. Head of fire must be stopped from working past the old diggings. Lines C-D and F-G are the immediate key sectors to accomplish this.
 4. Use immediately 10 men to backfire and hold line F-G (a gravel wash ; no line construction needed). Length 15 ch.
 5. Take the 30 men arriving at C at once and construct line C-D and backfire. Length 13 ch. Time 25-30 minutes. Lines F-G and C-D are vital.
 6. Pull men not needed on line F-G or C-D as rapidly as safe for work on sectors C-H and H-I.
 7. Next start a backfire at H proceeding to C. Length 25 ch.
 8. Simultaneously backfire down firebreak and road H-I, and thence down firebreak I-E to river, proceeding only fast enough to prevent head of main fire or backfire C-H from getting across H-I-E.
 9. As soon as wind shifts down canyon finish backfire to E.
 10. Get word to crew following up canyon from M-A and toward E to backfire on up canyon when wind shifts.
 11. Final area about 800 acres.
-

POINTS TO CONSIDER IN LINE LOCATION

1. Locate lines adequate distance from fire with respect to its probable rate of spread.
2. Plan lines far enough from the fire so that the available forces can build and backfire them out in advance of bad-burning conditions and they can therefore be held during such periods.
3. Pick out routes of easiest construction without sacrificing too much area, backfiring possibilities or holding practicability.
4. Locate lines to eliminate all possible hazards from fire areas, and avoid putting control lines close to hazards which must be included.
5. Avoid undercut lines and sharp angles.
6. Utilize all available barriers to reduce size of construction job and increase ease of holding line, with due consideration given to the resulting burned area.
7. Consider fully possibility of using machinery in constructing lines.
8. Provide for safety of men in planning all line locations.

SELECTING SECTOR FOR FIRST ATTACK

Foreword

On most fires the initial attack does not simultaneously consider all sectors. A choice is necessary, and on its correctness usually depends the outcome of the fire. There is thus a key sector, which if handled first makes control of the remaining sectors easier, more rapid, and surer.

Many factors, varying from fire to fire, determine this vital initial decision. The problems illustrate the more common ones.

SECTOR OF FIRST ATTACK

FIRST SECTOR SELECTED TO KEEP FIRE OUT OF MOST DANGEROUS FUELS

Problem 1

Conditions

Description of these given under line location, Problem 9, Figure 20, shows situation.

Solution Required

Assuming a fairly evenly advancing fire up the slope, at what point should the initial attack start and why?

Acceptable Solution

Start control action as close to the front of the fire as practicable (Line A-B) aiming to construct and hold line between the standing timber and the snag field. Go both ways on the line with the stronger force working around to head fire with enough men on flanks to prevent any possibility of outflanking.

SECTOR OF FIRST ATTACK

SELECTION TO CUT FIRE OFF FROM A STEEP SLOPE

Problem 2

USE FIGURE 27

Conditions

Region: East side, Zone 2.

Time of year: Mid-August.

Time of day when planning begins: 2:00 P.M.

Size of fire when planning begins: 100 ac.

Perimeter of fire when planning begins: 134 ch.

History to date: Fire started at point (x) at 12:00 noon and by 2:00 P.M. had spread north approximately 50 ch. The fire has spread in a southerly direction 10 ch. in 2 hours.

Weather, current: South to southwest wind, 10 mi. per hour; relative humidity, 15%; fuel moisture, 3.5%. No change predicted.

Elevation: Fire area and logged-over land to the north 5,000'. High timbered plateau south of fire, 6,000'.

Topography: Area north and east of base of steep slope E-F rolling and cut up with numerous short drainages.

Rate of spread types: Area north of base of slope E-F recently logged-over ponderosa pine, some slash and snags. From E-F to the top of the plateau the cover is heavy brush with patches of timber. Southwest of these heavy brush slopes the type is mature timber and scattered brush.

Resistance to line construction types:

- a. North and east of base of slope E-F—logged over—1.5 chains per man-hour.
- b. Brushy slope south and west of base of slope E-F .7 chains per man hour.
- c. Timber and brush on plateau south of brushy slopes 3 chains per man-hour.

Manpower: Can be secured as needed.

Equipment available: Hand tools only in adequate quantities.

Roads: Road to point E and 1/5 mile west of point B.

Solution Required

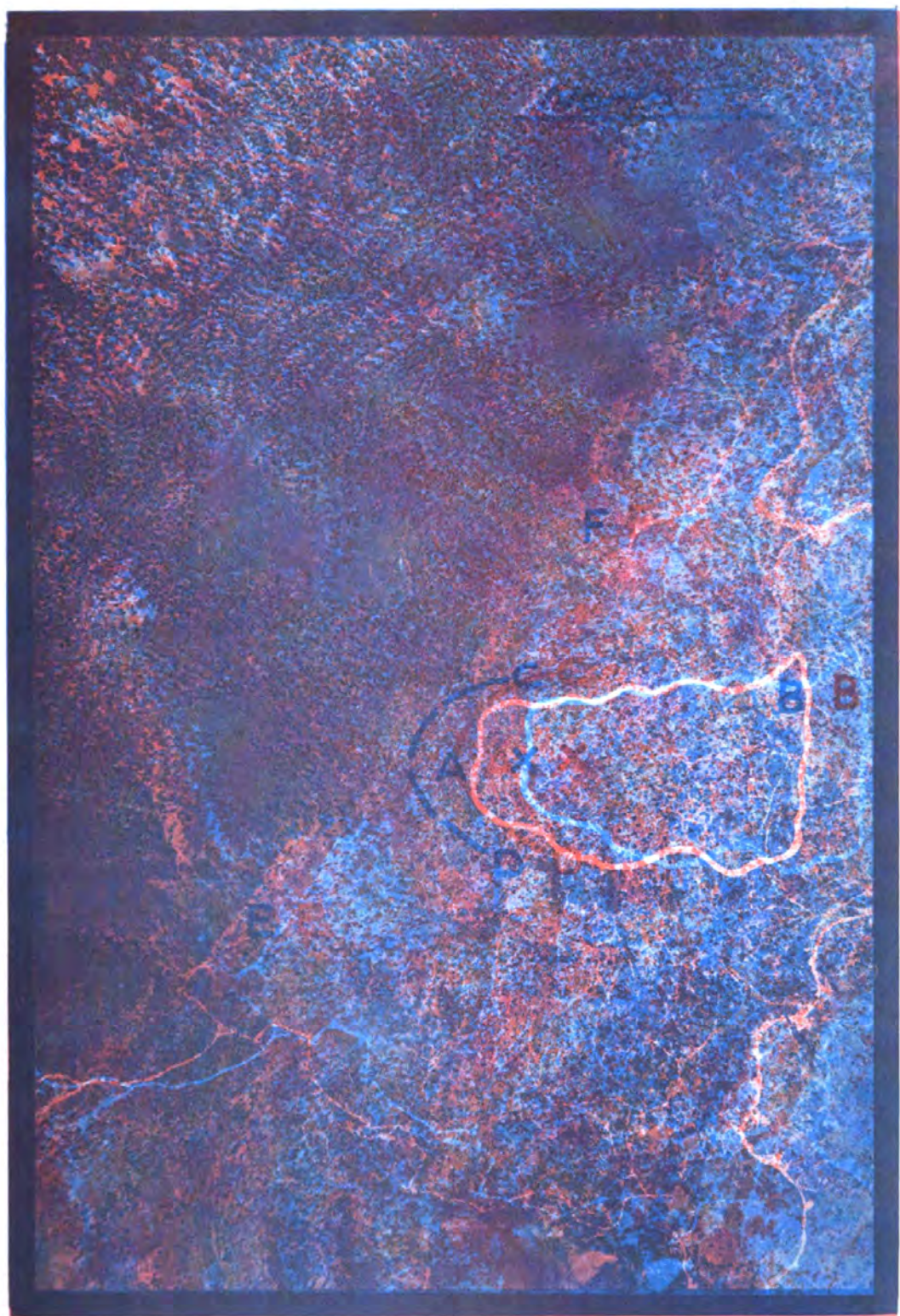
Where to make first attack when major topographic changes are involved.

Acceptable Solution

Keep fire out of steep, brushy slope to SW. first. Hence attack heel of fire first by constructing line C-D; as soon as control has been attained on this sector of the fire, hold this sector and apply effort to control head of fire, to be followed by tying in the sides. This priority of action will prevent the fire from gaining a foothold on steep, brushy slopes to the south of A.

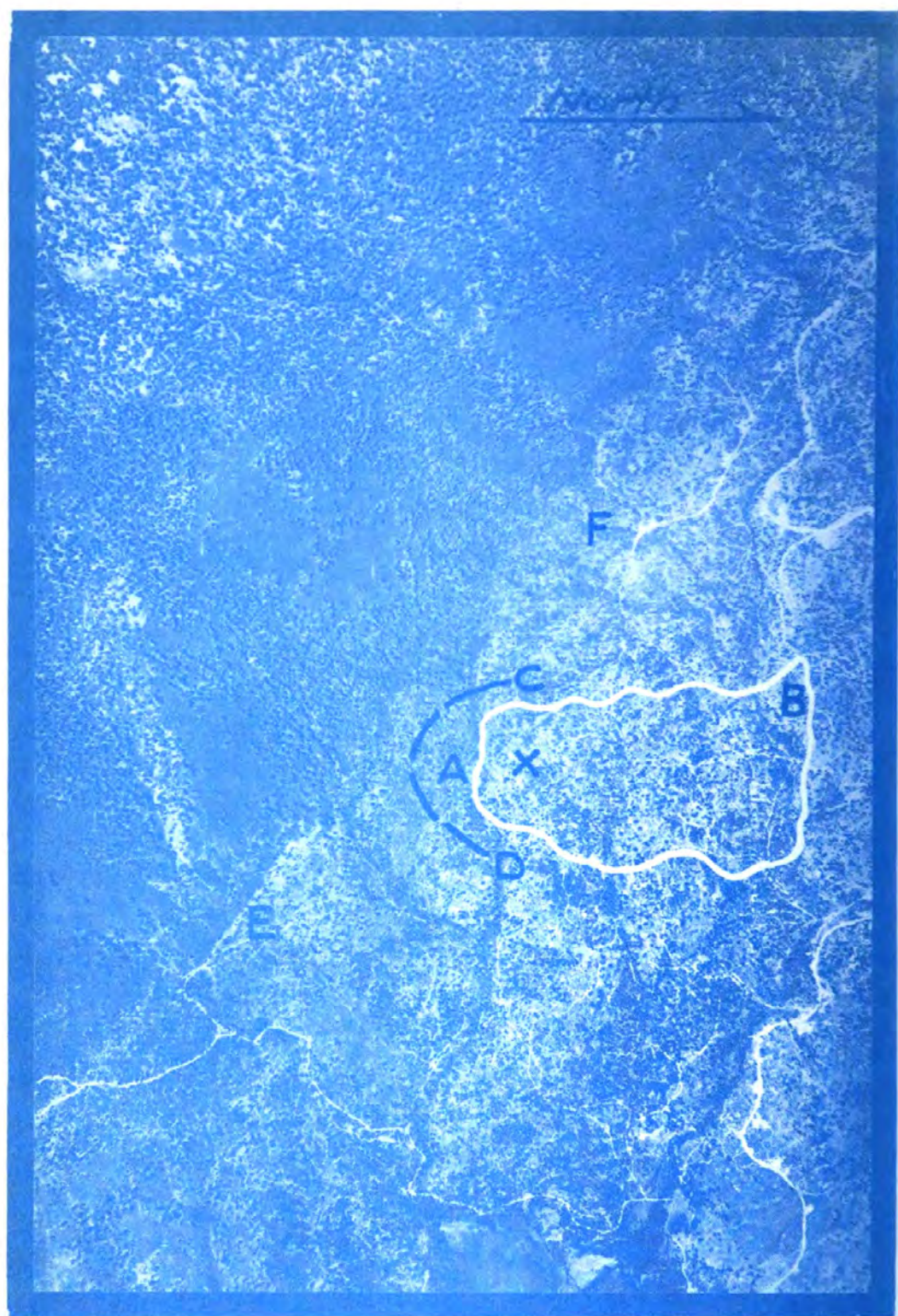
Supplemental

With the wind reversed: If possible, *attack at C-D first* for the same reason mentioned above. With the wind reversed this may not be possible under conditions existing at the time, but the principle of preventing fires from gaining a foothold on steep slopes should always be kept in mind when making first attack.



Scale 3'' = 1 mi.

Fig. 27



Scale 3'' = 1 mi.

Fig. 27



Fig. 28

5-28

B

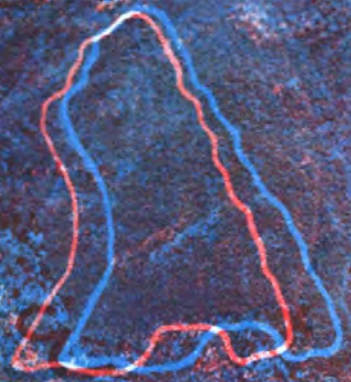


Fig. 28

SECTOR OF FIRST ATTACK
SELECTION TO CONFINE FIRE TO ONE MAJOR AREA

Problem 3

USE FIGURE 28

Conditions

Region: West side, Zone 2.

Time of year: July.

Time of day when planning begins: Noon.

Size of fire when planning begins: 70 ac.

Perimeter of fire when planning begins: 125 ch.

History of fire: Start 10:30 A.M. Fire had good start when 15-man crew arrived at noon. It was burning on both sides of a canyon with not over 1 ac. and 15 ch. involved in the smaller area (point C) northwest canyon where fire was burning in light brush and grass.

Current weather: SW. wind, very light, up canyon; relative humidity, 24%; fuel moisture, 5.5%. No changes in prospect.

Elevation: Low saddle, point A, 4,700'; river, point C, 4,200'; ridge, point B, 5,700'.

Topography: Steep, rugged slopes with deep canyons.

Rate of spread types:

- a. Slope south of point C heavy manzanita.
- b. Slope to top of ridge north and west of point C light manzanita and grass.
- c. Slope west and north of point A heavy manzanita.

Values: Rather low-value watershed.

Solution Required

What portion of the fire should be attacked first, and why?

Acceptable Solution

The smaller fire area on northwest side of canyon at point C should be controlled first in order to confine the main fire to one slope. If this small spot south of the river is not picked up immediately the fire will rapidly burn up slope C-A and will cross the low saddle at point A, resulting in a fire in three drainages with three heads. Would also get into heavy difficult cover west of point A.

SECTOR OF FIRST ATTACK

SELECTION AS CONTROLLED BY VALUES AT STAKE

Problem 4

USE FIGURE 29

Conditions

Region: West side, Zone 1.

Time of year: September.

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: 1,000 ac.

Perimeter of fire when planning begins: Gross 535 ch.; perimeter of fire front threatening Forest, 100 ch. (white line A-B); remaining fire controlled.

History of fire: Incendiary fire in adjacent territory protected by another agency had been burning for two days. The rear and flanks of the fire have been controlled but the head or east end of the fire is still untouched. The head of the fire (line A-B) finally reached fairly close to the Forest and the Ranger decided he would have to backfire a section of the Ponderosa Way to keep the fire from burning farther east into high-value country.

Weather: West to southwest wind, gentle; relative humidity, 20%; fuel moisture, 4%. Somewhat worse condition in prospect during the ensuing 24 hours, with heavier winds; humidity down to 12% and fuel moisture to 3.5%.

Elevation: 1,200' at point C.

Topography: Gentle with steady rise to Ponderosa Way from the west.

Rate of spread types: Manzanita, scrub oak, grass running into ponderosa pine.

Values: Relatively low-value grazing land below Ponderosa Way; second growth and much higher values above or east of this.

Manpower and equipment available: 80 men with backfiring equipment and a 290-gallon tank truck are on Ponderosa Way at point C.

Road: Entire length of Ponderosa Way C-D, also C-B and D-E.

Solution Required

What should the fire boss do? (1) Wait for the fire to come up to the break; or (2) Fire it out as soon as possible and start down the roads C-B and D-E on each flank; or (3) Go to A and B and work eastward toward Ponderosa Way.

Acceptable Solution

Backfire from Ponderosa Way as rapidly as safe and tie in the side lines back to dead territory (using available roads to extent feasible) to prevent flanking and a recurrence of the same trouble beyond the ends of the backfire line. The low values below the break justify some sacrifice in ultimate area to protect the higher values above it. A quick job is desirable to complete control before conditions become more hazardous and to release the men for possible duty elsewhere in view of prediction of worse conditions.

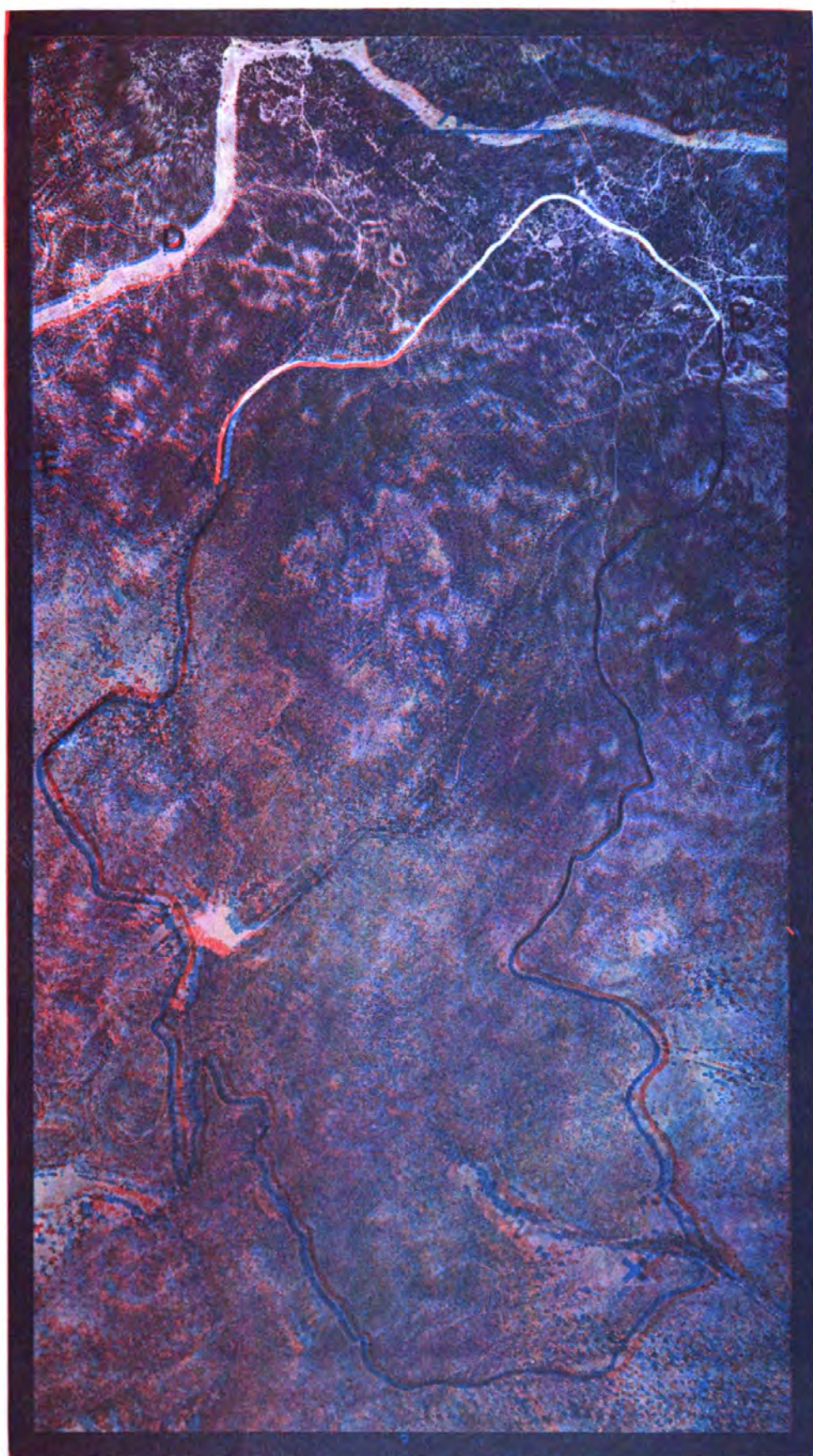


Fig. 29



Fig. 29



Fig. 30

Scale 3" = 1 mi.



Fig. 30

Scale $3'' = 1 \text{ mi.}$

SECTOR OF FIRST ATTACK

SELECTION SO THAT CONTROL LINE IS TIED INTO SOMETHING

Problem 5

USE FIGURE 30

Conditions

Region: West side, Zone 1.

Time of year: July.

Time of day when planning begins: 6:00 P.M.

Size of fire when planning begins: 70 ac. (area bounded by H-I-D-E-G-H).

Perimeter of fire when planning begins: 115 ch.

History of fire: Fire had been attacked at 3:00 P.M. by a man of rather limited experience with a crew of 20 men. Fire at this time shown by lines E-F-D-E. Despite his vigorous efforts he had nothing much to show for his work of some three hours except considerable lost line. He had put in and lost by outflanking three lines, A, B, C, starting at head and going down east side. Mobilization of men had continued and by 6:00 P.M., when the District Ranger arrived, he found on calculating the probabilities from the best available information, including data secured from an airplane flight, that he had enough men and machinery to handle the jobs ahead.

Weather: Normal conditions obtained and no change was anticipated for the next day. Wind very light, up slope; relative humidity, 30%; fuel moisture, 5.5%.

Elevation: River, 4,400'; ridge to north, 5,500'.

Topography: Steep canyon slope.

Rate of spread types: Manzanita growing back in a 4-year-old burn.

Barriers: Canyon bottom D-E has water in it and is about 30' wide.

Values: Low-value watershed; hence acreage losses, while important, are not too serious.

Solution Required.

Determine what was wrong with the initial attack and what essential change in plan of attack was imperative if fire was to be controlled within reasonable area limits.

Acceptable Solution

Guard's efforts made without adequate plan and program of action for complete job which needed to be done. One maxim of fire fighting is to tie lines into something definite and make everything secure to that tie. Leave no loose ends behind or openings through which the fire may slip. He should have either:

- Started along canyon D-E and worked either one or both flanks.
- Started work both to east and west from head of fire, working down toward canyon and not crowded the side so closely as to be out-flanked.

SECTOR OF FIRST ATTACK

SELECTION AS CONTROLLED BY IMPENDING PROBABLE SHIFT OF WIND

Problem 6

USE FIGURE 31

Conditions

Region: West side, Zone 1.

Time of year: August.

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: 10 ac. (smaller area enclosed by solid white line).

Perimeter of fire when planning begins: 35 ch. (12 ch. linear spread up slope).

History: Fire started 4:00 P.M. Ranger arrives on fire at 5:00 P.M.

Weather, current: SE. wind, 10 mi. per hour; relative humidity, 25%; fuel moisture, 5%.

Predicted: Weather conditions to remain same until 7:00 P.M. when wind expected to reverse and come from the NE. at rate of 8 mi. per hour.

Elevation: 5,000' bottom of main canyon, 6,500' top of ridge A-C.

Topography: Steep (50%) slope between river bottom B-D and ridge top A-C.

Rate of spread types: Dense low brush on steep slope. Rate of perimeter spread is 35 ch. per hour, linear spread up draw with wind 12 ch. per hour, linear spread down draw against wind 1 ch. per hour. When wind changes to NE. rate of linear spread to SW. 3 ch. per hour and perimeter spread is 7 ch. per hour.

Barriers: River in canyon forms good fire line but may be crossed easily by fire with wind. Bare ridge to west of fire (A-E) forms barrier which is generally safe if manned.

Manpower available: All needed can be on fire line at E, B, or C by 6:00 P.M.

Equipment available: Hand tools only. No machinery available for use in line construction.

Roads: Road along ridge A-C above fire.

Values: Uniform high timber values across ridge north of fire; low values on main canyon slopes.

Solution Required

1. Perimeter and location of fire when suppression work started (6:00 P.M.).
2. Time, place and sequence of attack.



Fig. 31

Scale 3" = 1 mi.

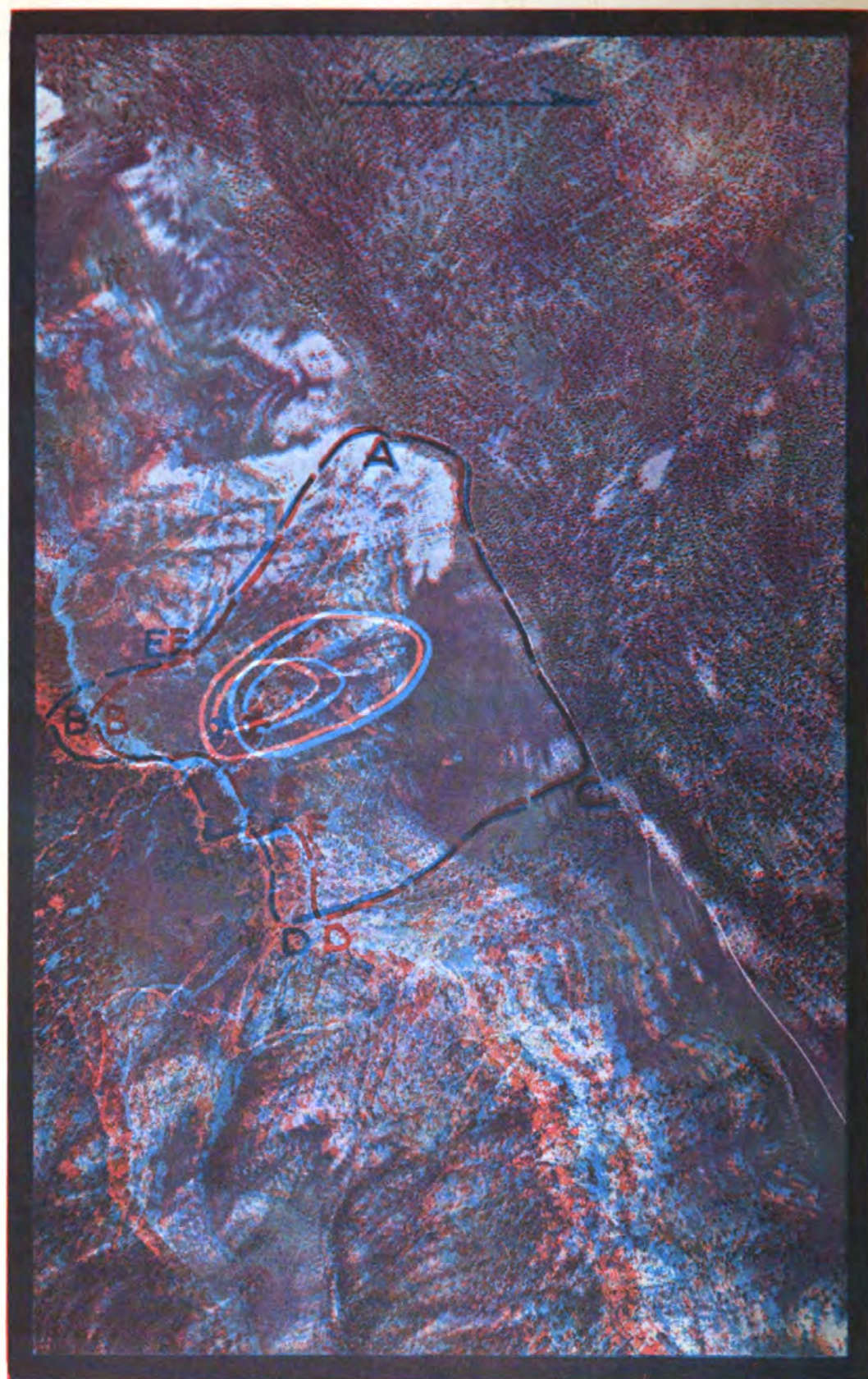


Fig. 31

Scale 3" = 1 mi.

Acceptable Solution

1. *Size and location:*

From 5:00 to 6:00 P.M. fire moves 12 ch. up steep slope (same linear rate as from 4:00 to 5:00 P.M.), increasing perimeter of fire to 70 ch. At 6:00 P.M. fire 5 ch. from river and 13 ch. from ridge A-C. Fire is then approaching ridge at rate of 12 ch. per hour and approaching river at rate of 1 ch. per hour. (See larger area enclosed by solid white line for location of fire at 6:00 P.M.)

2. *Sector of first attacks*

- a. Sector A-B is of first importance. However, since A-E is practically bare, only section E-B of this sector need be handled first. A fire line should be started from E, progressing towards B, followed immediately with a backfire.
- b. Sector B-F is of second importance, and as soon as line E-B is completed and backfired, sector B-F should be backfired from B to F. These two sectors should be completed prior to the wind change at 7:00 P.M.

Supplemental

When the wind reverses direction at 7:00 P.M., a line should be started at C, progressing towards D, followed by a backfire. Simultaneously a backfire should be started at C, following the road to A. A few men on line A-E for holding will also be needed. Line F-D is barren and will need very little attention.

SECTOR OF FIRST ATTACK

SELECTION BASED ON RECOGNIZING THE EFFECT OF THE DIFFERENCE IN ELEVATION ON VEGETATIVE READINESS TO BURN

Problem 7

USE FIGURE 32

Conditions

Region: West side, Zone 2.

Time of year: Mid-June.

Time of day when planning begins: 5:00 P.M.

History to date: Fire started in bottom of canyon at point (x) at 2:00 P.M. It spread up the slope as shown. One pronounced head had developed B with four others under way, C, D, F, G. Ranger with 50 men arrived at point G on old flume at 5:00 P.M. No other forces were on fire or on the way in.

Weather, current: Canyon bottom A-E, SW. wind up canyon, 8 mi. per hour; relative humidity, 20%; fuel moisture, 4.5%. Point B, wind up slope, 4 mi. per hour; relative humidity, 35%; fuel moisture, 15%, due to patches of melting snow in vicinity.

Predicted: Wind down canyon during the night; no other change.

Elevation: Point B, 5,500'; canyon bottom, 3,000'.

Topography: Very steep generally over fire area and immediately adjacent outside.

Rate of spread types: Grass, light brush along river bottom. Practically cured at lower elevation and just starting to grow at upper limit reached by fire. Some timber along river bottom and extending up slope to an elevation 1,000' above river; remainder mixed brush, largely manzanita, medium to very dense.

Solution Required

Determine points of attack based on condition of cover.

Acceptable Solution

- a. First attack and knock down heads C, D and F, to prevent additional major heads from developing, then build line as soon as possible around E-F-D-C.
- b. Build line from A toward G and backfire portion of line where vegetation is cured or of high hazard.



Fig. 32

Scale 2" = 1 mi



Fig. 32

Scale 3'' = 1 mi.

- c. Upper or south end of fire, including points B and G, can be controlled with fire line later after north or lower half of fire is controlled.

The reason that the minor heads are attacked first is that the fuel moisture, due to difference in elevation, is much lower along the river and up the slope a short distance than at points B and G, which are in the vicinity of melting snow with ground cover in an unflammable condition.

Attacking and preventing spread of fire in cured vegetation, with delayed action on lines where burning conditions are not dangerous, is good practice.

SECTOR OF FIRST ATTACK

SELECTION TO UTILIZE EXISTING BACKFIRING LINE

Problem 8

USE FIGURE 33

Conditions

Region: Southern California, Zone 1.

Time of year: September.

Time of day when planning begins: Late afternoon.

Size of fire when planning begins: 96 ac.

Perimeter of fire when planning begins: 160 ch.

History of fire: Fire started around 3:00 P.M. by a careless smoker who was hiking through the country on an old trail. Fire started in a brush-covered basin at the foot of a large mountain which was part of the main divide. On top of this divide is a well-cleared firebreak A-D from 40 to 60 feet wide. Initial attack had been able to do little on fire which was badly spotted and very irregular in shape.

Current weather: SW. wind, light; relative humidity, 22%; fuel moisture, 5%; wind unchanged for next 24 hours.

Elevation: 2,500' to 4,500'.

Topography: Steep after leaving small basin up to top of sharp ridges.

Types: Chaparral 10' to 20' high in basin and 4' to 5' high near ridge tops, where poorer site quality.

Manpower available: A crew of forty men had been moved to the firebreak (point A) on the main divide below which the fire was making runs part way up the slope, but still some little distance below it. A crew of 40 men was located at point D also.

Values: The watershed in which the fire was burning was of high value because it was directly above some expensive flood-control structures the rate of silting of which would be greatly increased if the brush cover were destroyed by fire. The canyons into which the fire would run if it crossed the break A-D are, however, of even greater value from a watershed and flood control standpoint.

Solution Required

What should the fire boss do with the crews on the firebreak A-D? Should he wait for the fire to come up to the break or backfire this as fire approached at different points?

Acceptable Solution

Past experience indicates there is little chance of the firebreak holding unless backfired out. The firebreak, therefore, should be fired out as rapidly as possible. Then effort must be concentrated on picking up the sides and rear of the fire. Priority of backfiring lines A-D, A-C, and D-B. Hand lines from C to E to B must be built and backfired subsequently.

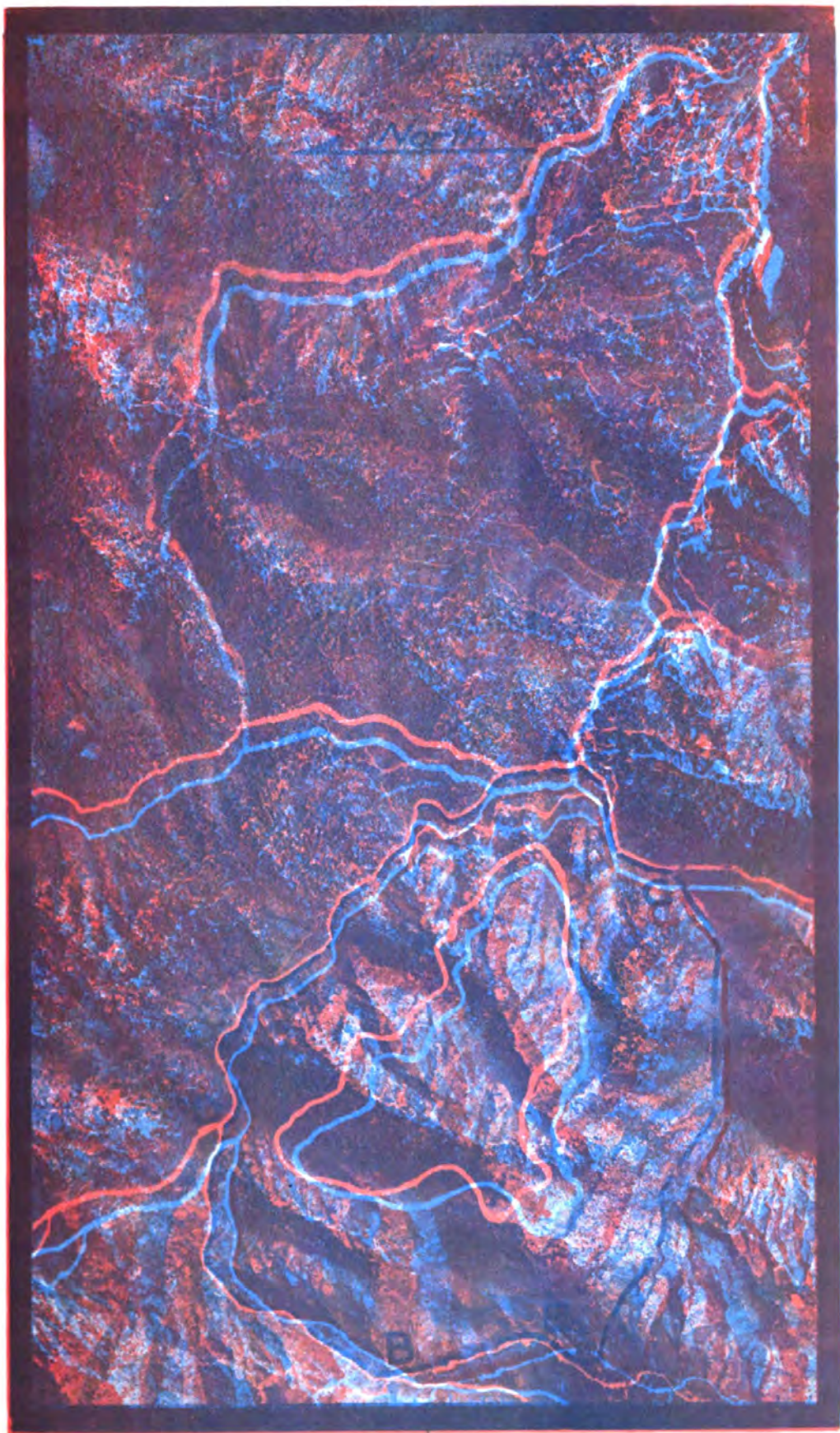


Fig. 33

Scale 3" = 1 mi.

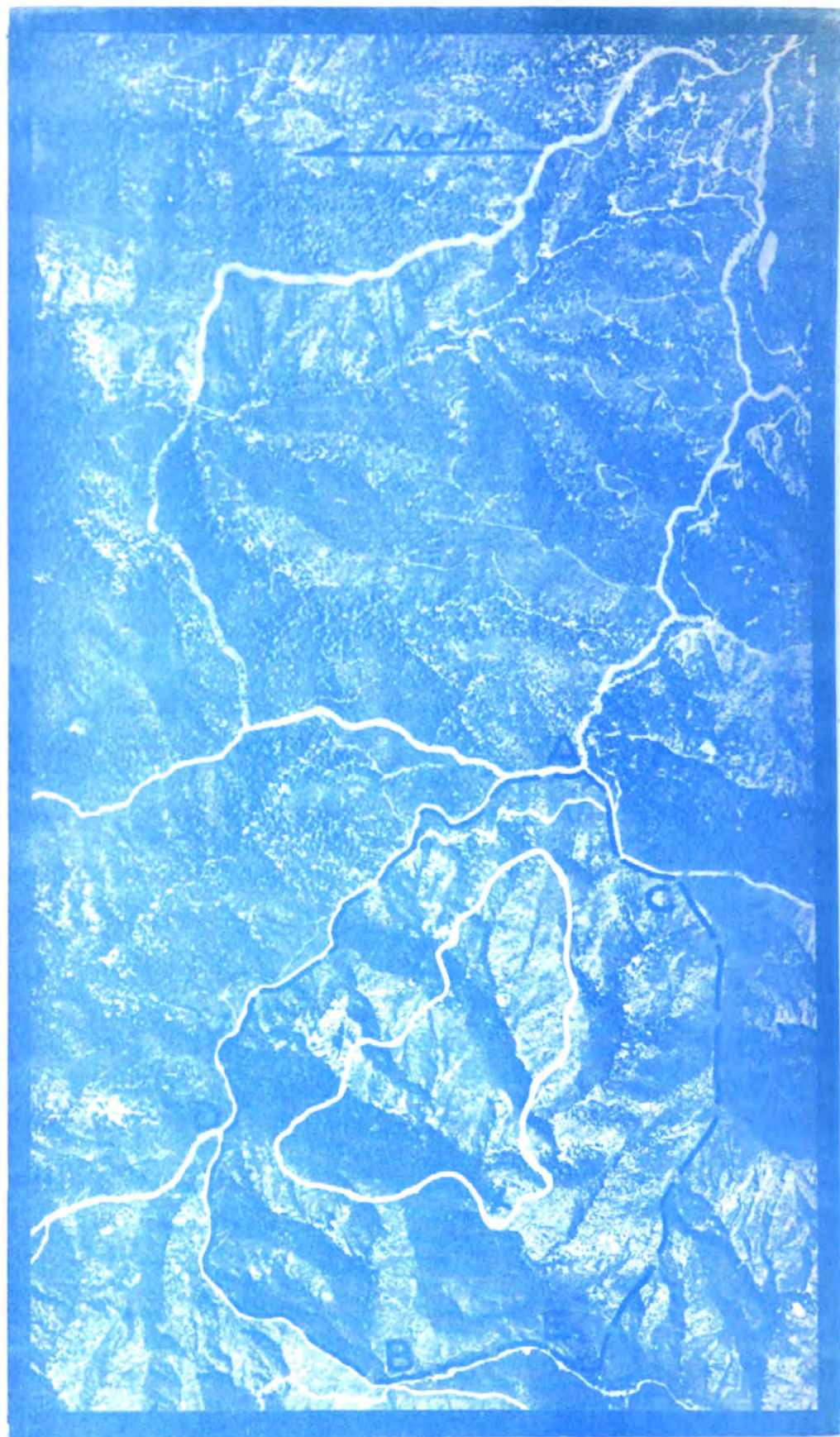


Fig. 33

Scale 3" = 1 mi.



Scale 3" = 1 mi.

Fig. 34



Scale 3" = 1 mi.

Fig. 34

SECTOR OF FIRST ATTACK

SELECTION WHEN NO COMPELLING REASON FOR SOME PARTICULAR SECTOR

Problem 9

USE FIGURE 34

Conditions

Region: East side, Zone 2.

Time of year: August.

Time of day when planning begins: 4:00 P.M.

Size of fire when planning begins: 120 ac.

Perimeter of fire when planning begins: 130 ch.

History of fire to date: Fire got off to a very fast start with conditions very dry.

Weather: Negligible wind; relative humidity, 6%; fuel moisture, 2%.
No change in prospect next 24 hours.

Elevation: 5,600'.

Topography: Gently rolling.

Rate of spread types: Open ponderosa pine with occasional sagebrush flats. Cover uniform.

Solutions Required

Does it make any difference where the initial attack is made on this fire?
Where should this be made in the interest of economy of effort?

Acceptable Solution

Since there is no head to the fire which is spreading pretty much in all directions, the point of first attack can well be the place which suppression forces reach first. Time will be saved if action is not delayed and the first crew starts going both ways on the fire at the point reached first. Fire lines are of course tied together and maintained as each crew advances.

SECTOR OF FIRST ATTACK

SELECTION CONTROLLED BY MOST EFFECTIVE USE OF AVAILABLE SPECIALIZED EQUIPMENT

Problem 10

USE FIGURE 35

Conditions

Region: Southern California, Zone 1.

Time of year: September.

Time of day when planning begins: 2:00 P.M.

Size of fire when planning begins: 17 ac.

Perimeter of fire when planning begins: 70 ch.

History to date: Fire started in grass and buckwheat (point x) in steep country at 1:30 P.M. Tanker and five-man crew arrived on the road above the head of the fire at 2:00 P.M. (point A).

Current weather: Light NW. wind; relative humidity, 20%; fuel moisture, 4%.

Topography: Medium slope.

Rate of spread types: Open grass and buckwheat with occasional clump of low chamise.

Equipment: Full 260-gallon tank truck above head of fire on road.

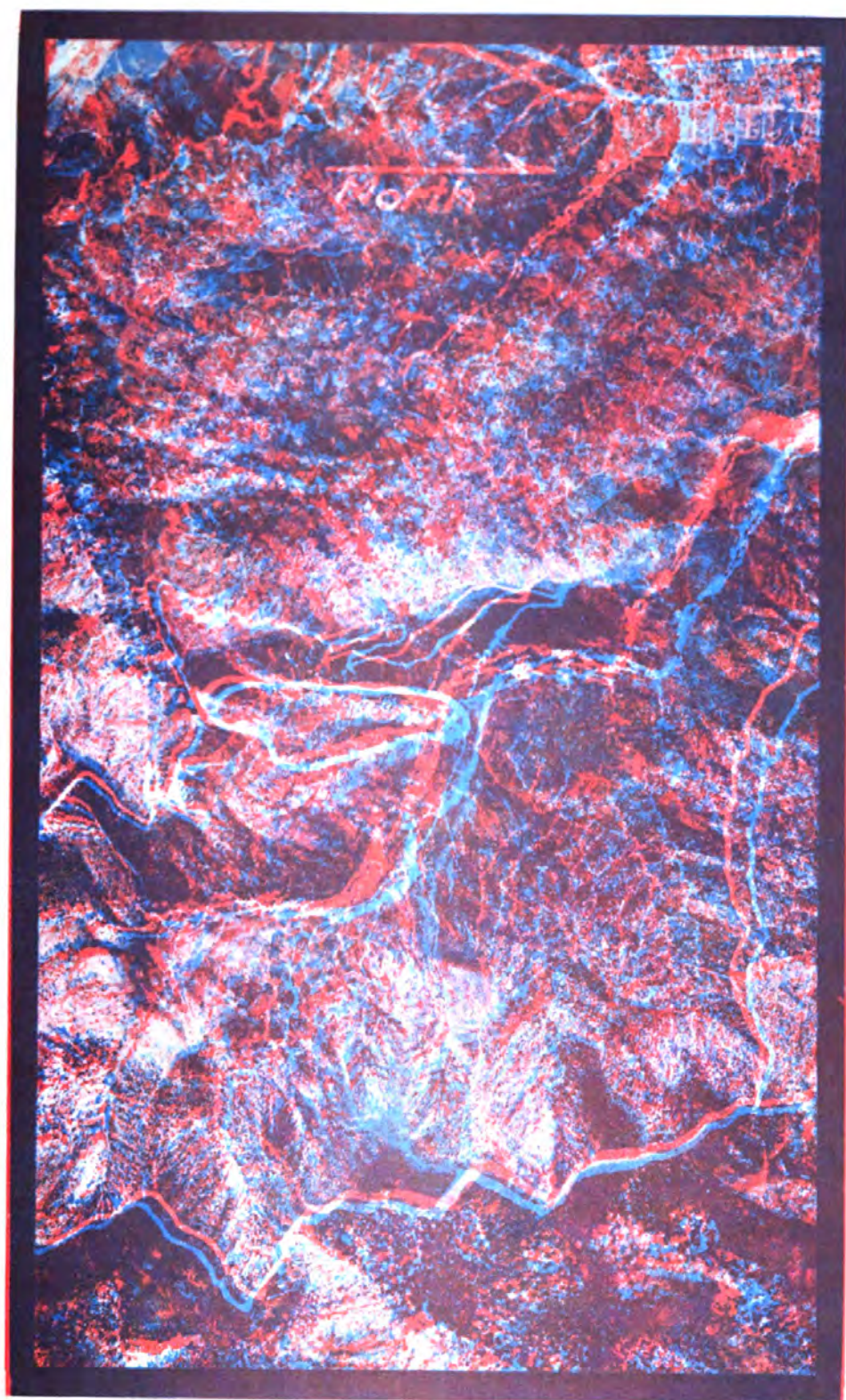
Values: High values across road, south of point A.

Solution Required

What should crew do on initial attack?

Acceptable Solution

Head of fire certain to cross road into very high-value area unless stopped at once. Fire was burning hotly, thus tanker crew should start work on the head and cool it down where it hits the road on a front of 4 ch. in width at point A. As this calmed down the crew should install a siamese and start to work down both side lines up which other crews were coming from below and complete the job with hand tools. Head attack on fires of this kind is possible only if water is available, but it is very much worth while to make such an attempt to stop the forward run of a fire.



Scale 3" = 1 mi.

Fig. 35



Scale 3" = 1 mi.

Fig. 35

SECTOR OF FIRST ATTACK

SELECTION CONTROLLED BY AVAILABILITY OF TRACTOR

Problem 11

USE FIGURE 36

Conditions

Region: East side, Zone 1.

Time of year: August.

Time of day when planning begins: 3:00 P.M.

Size of fire when planning begins: 120 ac., 85 ch. long.

Perimeter when planning begins: 185 ch.

History to date: Started along highway at 1:00 P.M. in flash fuel; fire took off at once; first attack from highway by 5 men; started working up flanks. One RD-7 tractor trailbuilder and driver available on road (point A) near ridge west of fire. Reinforcements coming in piecemeal used to speed up attack on flanks and to assist tractor trailbuilder.

Weather, current: Wind up slope, 12 mi. per hour; relative humidity, 16%; fuel moisture, 3.5%.

Predicted: Slight reduction in wind and relative humidity beginning at 7:00 P.M.

Elevation: Start 4,500', top of ridge 6,000', point A west of ridge 5,500'.

Topography: Medium slopes; well-defined ridge top B-C; west of ridge B-C high plateau.

Rate of spread types: Flash fuels (bronco grass and scattered brush) at start; medium mixed brush to ridge; scattered timber and brush for $\frac{1}{2}$ mile beyond ridge, then cutover timber with medium brush and reproduction; good stand virgin ponderosa pine south of point A.

Barriers: None.

Equipment: One RD-7 tractor trailbuilder unit, point A, $\frac{1}{4}$ mi. west of ridge.

Roads: Road $\frac{1}{4}$ mi. west of ridge B-C; few old logging roads on plateau ahead of fire; road below origin of fire.

Values: Virgin timber south of point A and residual stand on cutover area to the north.

Solution Required

Most effective selection of first attack sector to use tractor to advantage.

Acceptable Solution

History of fires on similar mountain ridges is that they build up such power before reaching the divide that their momentum carries from 20 to 40 ch. after reaching ridge before they can be effectively stopped with hand labor attack. The fire will, however, slow down materially after crossing the ridge B-C, due to decrease in wind velocity and to down-hill spread of the front. Decision was to have tractor build line from crest of ridge along line B-A-D and use the men who come in and can be spared from flank attack to backfire and hold the tractor line. It was not feasible to build the tractor line on the main ridge B-C because spread was too rapid, the fire was too close and men to fire it out and hold this line were not available. Fire was expected to cross main ridge B-C at 3:30-3:45 P.M., allowing insufficient time for tractor to reach ridge and construct line along it. On the other hand, tractor can start on line B-A-D immediately and can work flanking the fire along this line. Tractor can build this line at rate approximately 30 ch. per hour.

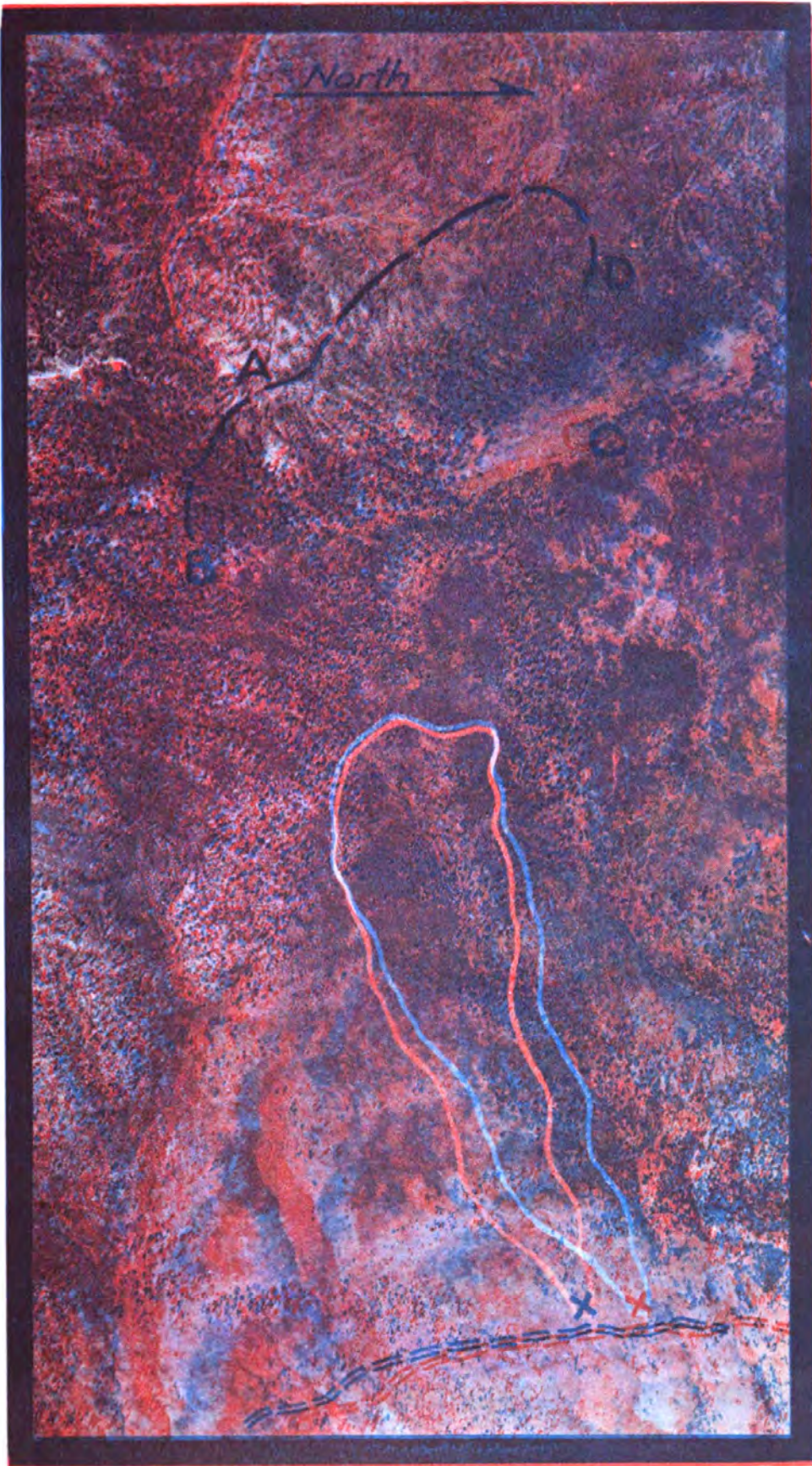


Fig. 36

Scale 3" = 1 mi

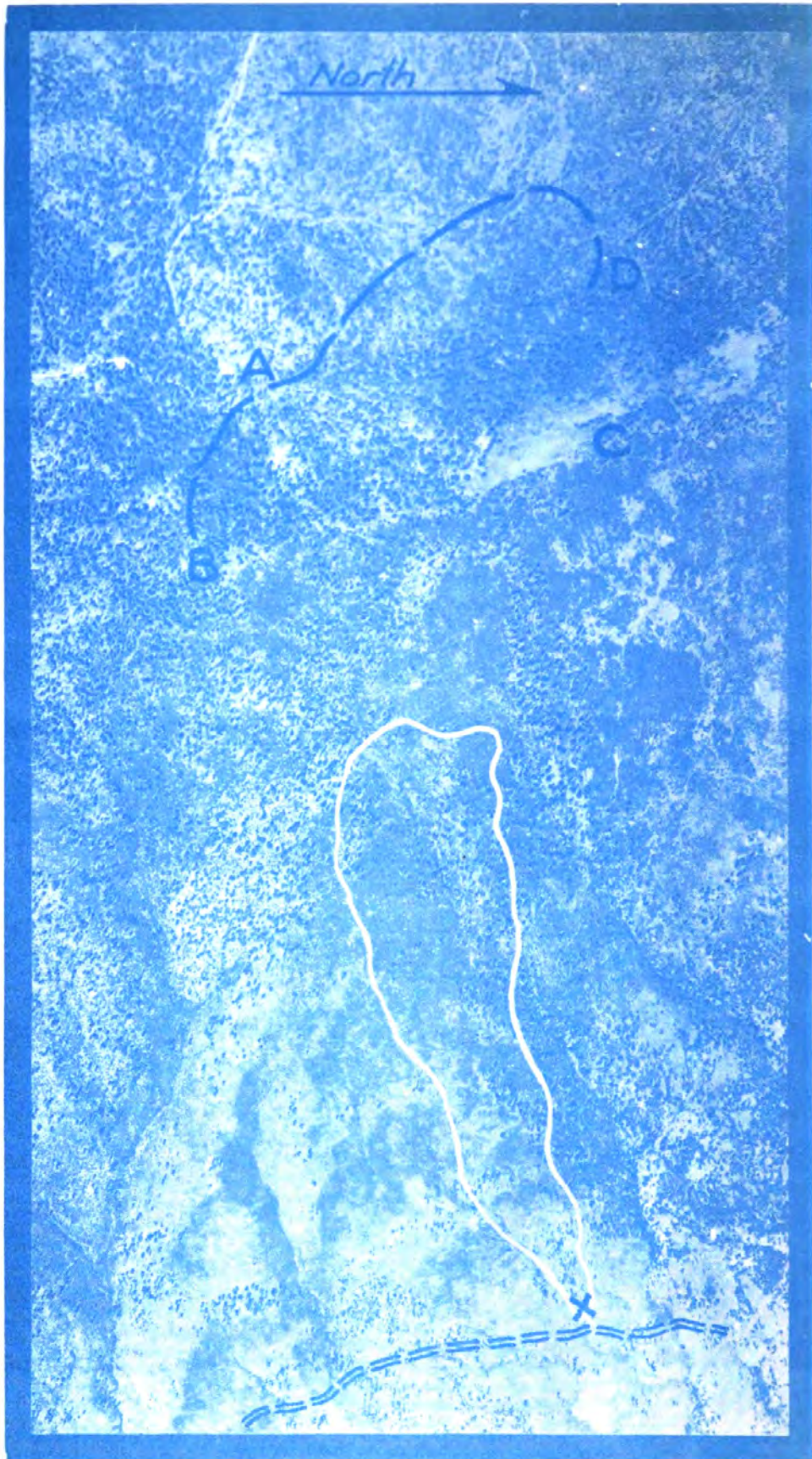


Fig. 36

Scale 3" = 1 mi

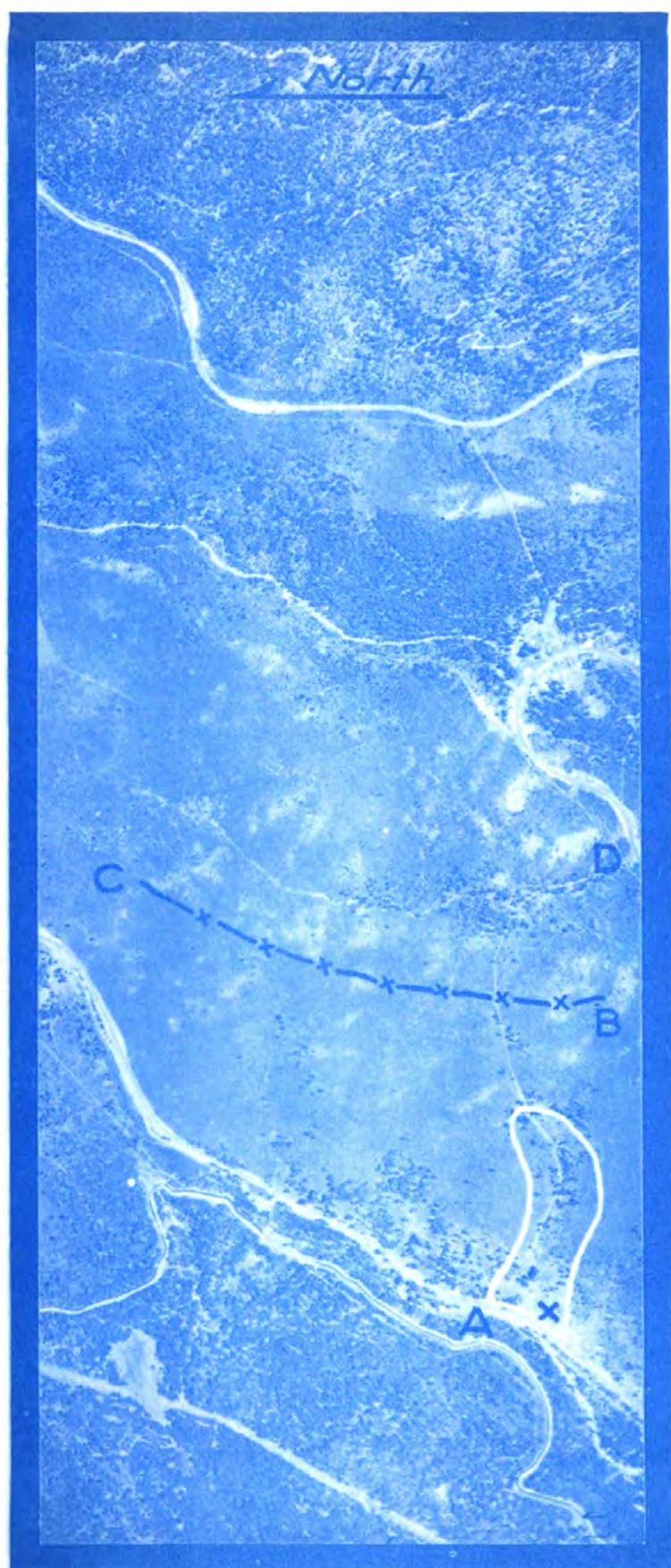


Fig. 37

Scal

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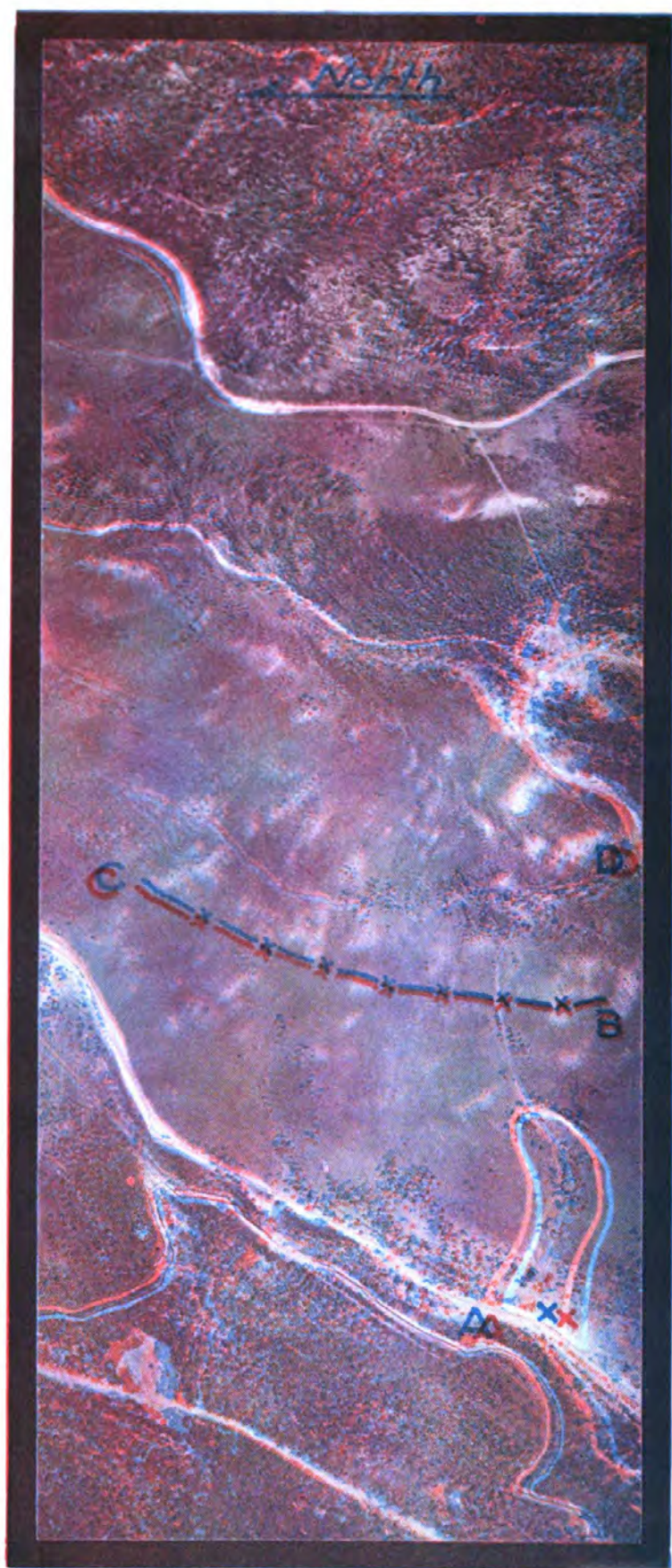


Fig. 37

ScalP

11

SECTOR OF FIRST ATTACK
SELECTION AS CONTROLLED BY SAFETY OF MEN

Problem 12

USE FIGURE 37

Conditions

Region: West side, Zone 1.

Time of year: September.

Time of day when planning begins: 2:00 P.M.

Size of fire when planning begins: 200 ac.

Perimeter of fire when planning begins: 210 ch.

History to date: Fire started at 12:30 P.M. Efforts to stop fire on cleared telephone line were unavailing.

Weather: Normal for time of year, with no changes predicted in next 24 hours.

Elevation: 5,000'.

Topography: Moderate slopes; fire burning up onto plateau.

Rate of spread types: Heavy mixed brush, white thorn and manzanita.

Barriers: Highway on lower edge; telephone line A-D through fire and parallel to its axis of spread. Narrow trail B-C on ridge above fire.

Manpower: 100 men. No machinery on job.

Solution Required

Should fire boss (1) man the trail B-C and try to stop fire there by backfiring or (2) make a rear attack working up the sides, in either event holding rear on the highway.

Acceptable Solution

Fire is spreading rapidly and its natural direction of spread is directly against the trail. This is quite narrow and in heavy brush. At present rate of linear advance fire will reach trail in about one hour (3:00 P.M.). Safety dictates that rear attack is only possible way to handle the fire without unwarranted danger to men.

SECTOR OF FIRST ATTACK

LOCATION CONTROLLED BY PROBABLE BEHAVIOR OF FIRE AND TIME OF DAY

Problem 13

USE FIGURE 38

Conditions

Region: East side, Zone 2.

Time of year: August.

Time of day when planning begins: 3:00 P.M.

Size of fire when planning begins: 3 ac.

Perimeter at time planning begins: 30 ch. (linear distance = 13 ch.).

History: Fire started at 2:00 P.M.

Weather: S. wind, 8 mi. per hour; relative humidity, 25%; fuel moisture, 5%. Weather reports indicate wind expected to reverse and come from north at 5:30 P.M. with increase in velocity to 15 mi. per hour.

Elevation: 6,300', point A. 7,000' main ridge to north.

Topography: Rolling medium slopes.

Rate of spread type: Recent slash. Perimeter rate of spread with 8 mi. wind and 20% slope is 30 ch. per hour.

Manpower available: Can be on job in numbers needed by 4:00 P.M.

Equipment available: RD-7 trailbuilder is ready for fire line use at 4:00 P.M.

Solution Required

At what point should initial attack be started, considering particularly time of day and anticipated fire behavior?

Acceptable Solution

1. Fire boss figures that with the rate of spread already encountered (linear spread = 13 ch. per hour) head will not cross the main ridge to enter the drainages to the north by 5:30 P.M. (time wind direction expected to reverse) so this eliminates immediate necessity of trying to control the head.
2. Rear attack is accordingly determined upon with forces divided and from point A started both ways with trailbuilder around the rear and up the flanks A-B and A-C with the object of making the rear safe so that when it becomes the head as the wind changes direction and increases in velocity at 5:30 P.M. fire's progress to the south will be stopped.

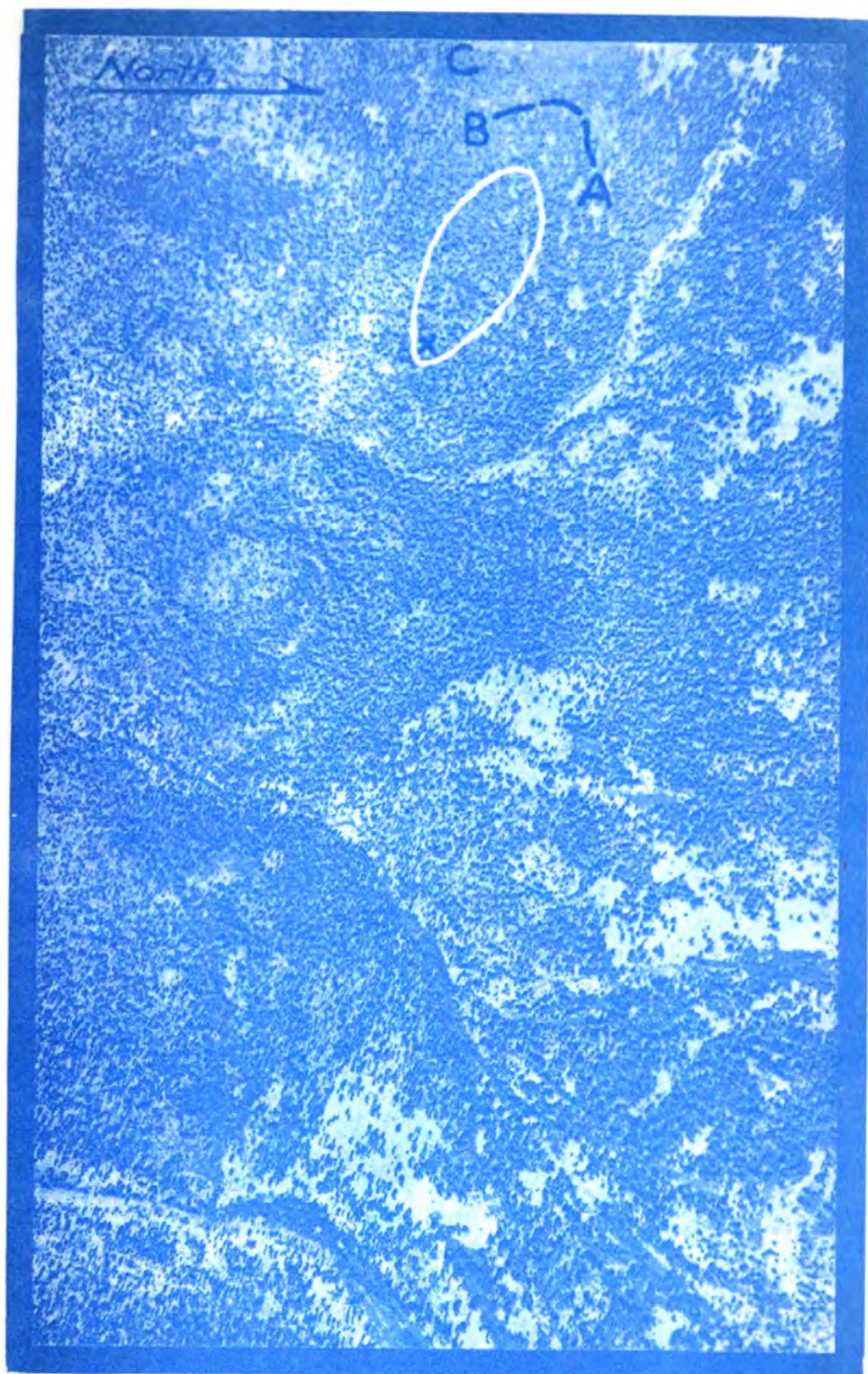
See larger area enclosed by solid white line for estimated location of fire at 4:00 P.M.

North →



North →





Scale 3" = 1 mi.

Fig. 39



Scale 3" = 1 mi.

Fig. 39

SECTOR OF FIRST ATTACK

SELECTION BASED ON PROBABLE BEHAVIOR OF FIRE

Problem 14

USE FIGURE 39

Conditions

Region: East side, Zone 2.

Time of year: July.

Time of day when planning begins: 1:00 P.M.

Size of fire when planning begins: 20 ac.

Perimeter of fire when planning begins: 70 ch., 30 ch. long.

History to date: Start 11:00 A.M.; first attack by guard and 9 men at 12:00 noon failed; Ranger arrives at 1:00 P.M. with 10 men.

Weather, current: SE. wind, 6 mi. per hour; relative humidity, 20%; fuel moisture, 4.5%.

Predicted: Practically no change for next 24 hours.

Elevation: Base of fire 4,200'; head of fire 4,500'.

Topography: Plateau, shallow drainage running east and south.

Rate of spread types: Ponderosa pine (35 ch. per hour).

Resistance to line construction types: Ponderosa pine, medium brush and reproduction, expected output 1.4 chains per man-hour for fresh men.

Manpower available: No more till about 5:00 P.M.; then 20 more.

Equipment available: Hand tools only.

Road: To point C.

Solution Required

Selection of sector (head or rear) for first attack.

Acceptable Solution

1. Fire is making 15 ch. per hour linear advance.
2. If head is unchecked it will be 90 or $(30 + 60)$ ch. long by 5:00 P.M. when additional men arrive.
3. If 20 men are divided and start work from rear on flanks they will construct and hold 50 ch. by 5:00 P.M. and by that time total perimeter (including held line) will be 210 ch. This means that even with the 20 additional men who are due to arrive at 5:00 P.M. it will be impossible to round up the fire on this plan of attack by early morning granting that the rate of spread during the night will be somewhat slower than in the day.
4. The only other alternative is to stop the forward progress of the fire by attacking it at the head. Beginning at 2:00 P.M. fire boss selects a suitable location about 10 ch. ahead of the fire, line A-B and builds a line with his 20 men across the front which is promptly backfired to a length of about 20 ch. by around 3:00 P.M. He can then start down each flank and if he has reasonable success will produce 30 or 35 ch. more held line by 5:00 P.M. when reinforcements will start to close in rear.

SECTOR OF FIRST ATTACK

SELECTION WHEN CONDITIONS REQUIRE SIMULTANEOUS ATTACK ON TWO OR MORE SECTORS OF A FIRE

Problem 15

USE FIGURE 40

Conditions

Region: West Sierra.

Time of year: Early September.

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: 90 ac.

Perimeter of fire when planning begins: 140 ch. (50 ch. forward spread).

History to date: Fire started at point (x) at 3:00 P.M. and spread rapidly in a northeasterly direction.

Weather, current: West to southwest wind, 15 mi. per hour; relative humidity, 20%; fuel moisture, 4.5%.

Predicted: Velocity of wind will gradually decrease, other factors unchanged.

Elevation: 4,000' point (x).

Topography: Numerous long and narrow ridges, draws shallow approximately 500' deep.

Rate of spread types: Medium to dense stand of mature sugar-pine, ponderosa pine, white fir; brush areas medium to dense stand of manzanita and mixed brush. Cover along ridge tops somewhat lighter than on side slopes or in canyon bottoms.

Road: F-E-A only road in area.

Manpower: All necessary at points A and E.

Water available: Point F.

Solution Required

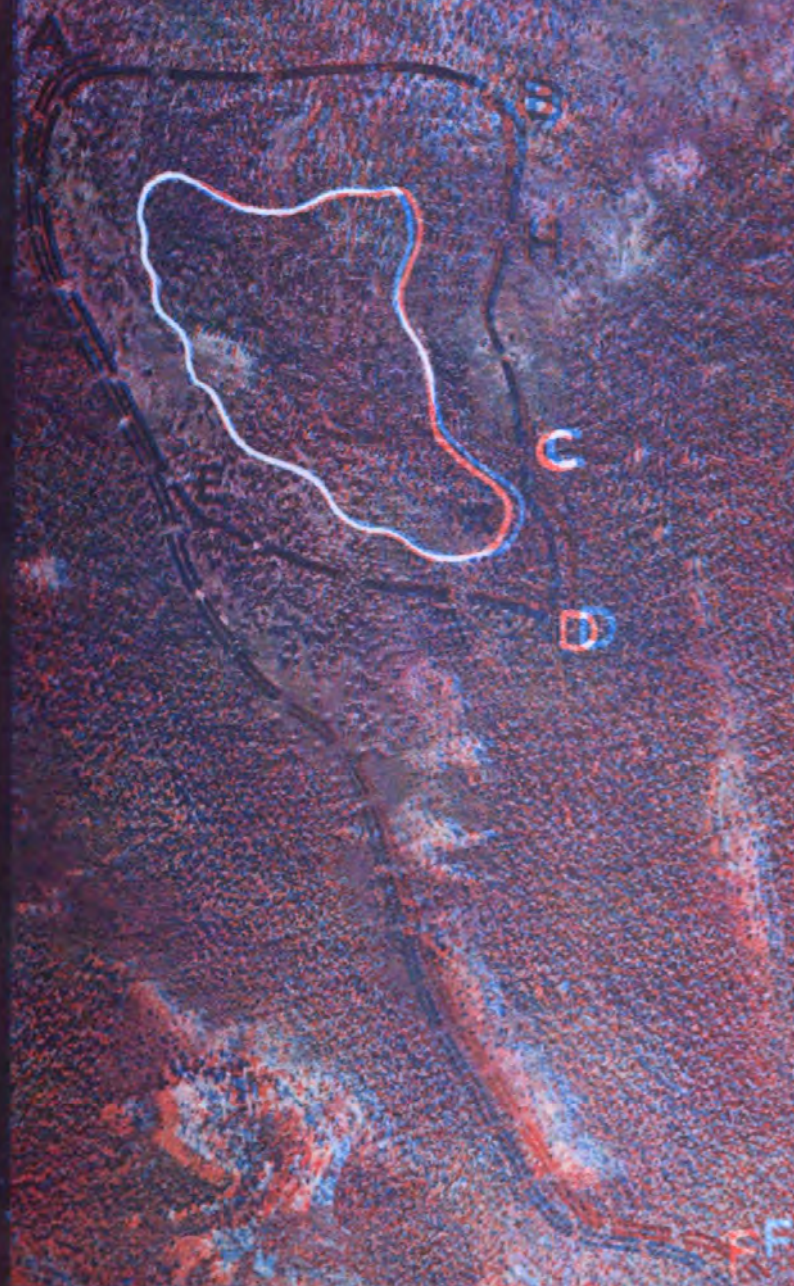
Where should the initial attack be made?

Acceptable Solution

1. The conditions are such that the initial attack on this fire should be made almost simultaneously on three points, namely in order of priority:

Point C. The fire is approaching bottom of draw and if action is not taken the fire will cross to the south side of the draw outflanking the men who may be working along line B-C and becoming established in the valuable stand of timber to the south which makes it imperative that this sector of the fire be controlled.

North



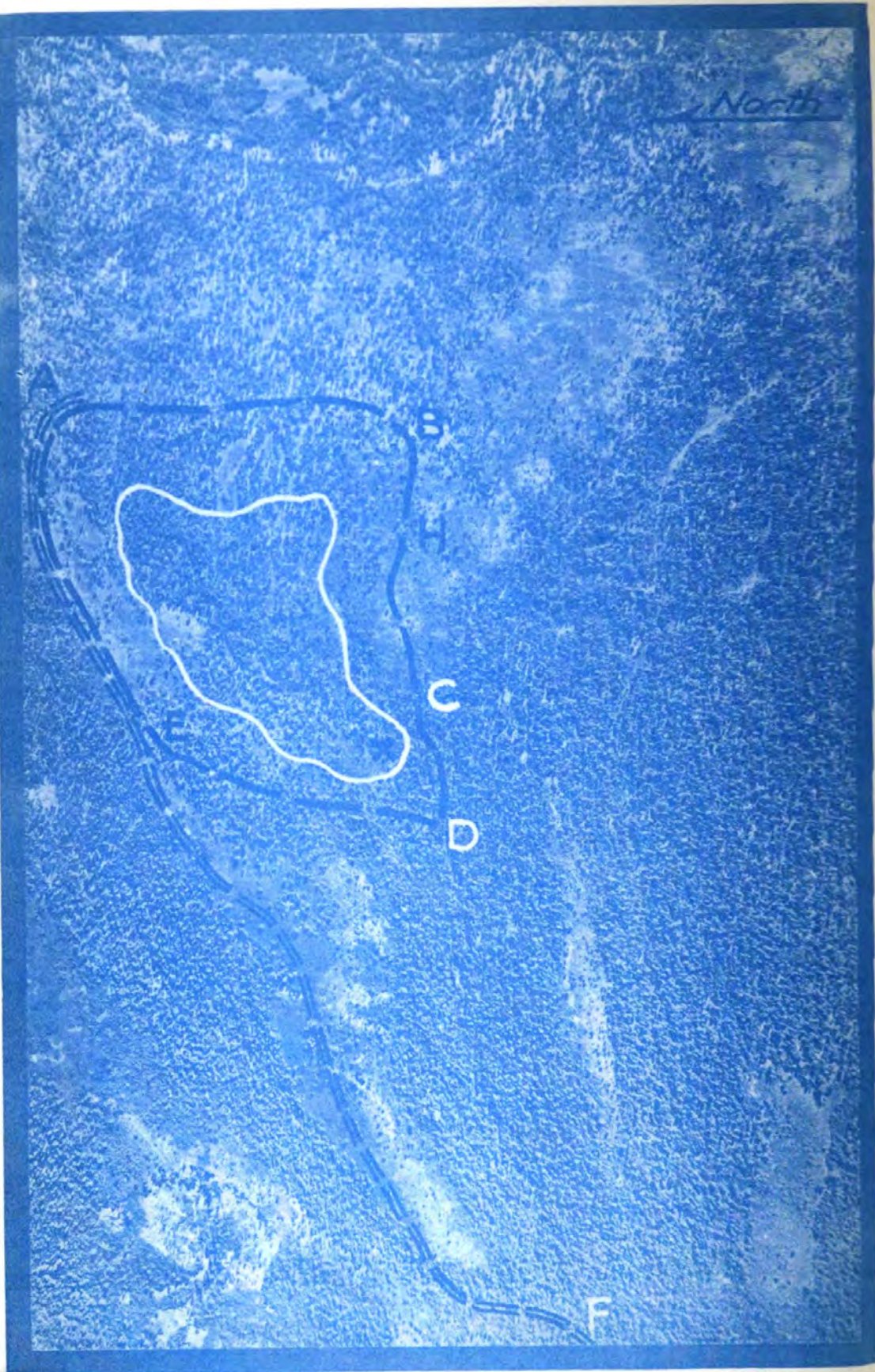


Fig. 40

Scale 3" = 1 mi.

Point A. The fire is approaching the saddle between the two drainages. If this point is not attacked immediately the fire will be in two major drainages, creating a much more difficult situation.

Point B. This point must be controlled since the fire will soon hit the top of the ridge in this vicinity. This will result in the fire getting into two major drainages; also once the fire crosses the secondary ridge B-H it will be necessary to drop down to the creek with the control line to eliminate roll, with a consequent increase in area burned and work to be done.

Supplemental

The final lines to control this fire are located as follows:

- a. Road E-A.
 - b. "A" south to low saddle, thence along ridge to B.
 - c. Ridge B-C.
 - d. Creek C-D.
 - e. D-E located on an angle to prevent material rolling over line.
-

POINTS TO CONSIDER IN SELECTING FIRST ATTACK SECTORS

1. Consider fully the accumulated knowledge of fire behavior in deciding where to make initial attack on fires.
2. Cut fires off from most dangerous fuels.
3. Prevent fires from coming out of explosive fuel types with a rush.
4. Confine fires to one major drainage if possible by controlling first the smaller unit of fire that has invaded two drainages.
5. Consider relative values and try to prevent fire from getting from lower value country to that of higher value.
6. Be sure initial attack is tied into something that will hold and continue to tie work done together without loose ends behind.
7. Where it is possible to stop the run of a fire by a head attack make such an effort.
8. Take full advantage of available machinery in deciding where to make first attack on fires.
9. Be sure men are properly safeguarded.

SCOUTING

Foreword

On scouting depends the accuracy, completeness, and up-to-dateness of the information available to the fire boss for his planning. Because several methods are available for obtaining this information, certain routines and priorities are often useful in making scouting most effective.

SCOUTING FOR FIRST PLAN OF ATTACK ON GOING FIRES

Purpose

Obtain and give fire boss information promptly.

Sources of Information

1. *Lookouts*—for spread, location and cover types of fire and apparent condition, control on lines.
2. *Maps*—Hazard zone, roads and trails, etc., water, character of topography.
3. *Aerial photos*—where available. Use with mirror stereoscope will give detailed picture in relief of cover, topography and all natural and artificial features which bear on control plan.
4. *Other Forest Officers and reliable ranchers and other locals.*
5. *Special field trips* by qualified men. Plan these *only* after all above used to fullest extent. Plan to fill in gaps of information. Use men such as truck trail locators who are expert in reading and preparing maps. Fire bosses must not tie themselves up on the work on large fires but should have competent men assigned to handle it at an early stage.
6. *Radio*—Setup so scout can report back out by radio without coming in himself.
7. *Airplanes*—Use where above methods fail to give all essential required information. Not merely to verify information already obtained.
8. *Photographs* taken of the fire currently from airplanes.

Kinds of Information—Essential to fill existing gaps in following information:

1. Actual location and progress of fire on all fronts, including badly spotted areas.
2. Types, topography and barriers ahead of fire by sectors or fronts.
3. Possible location of lines to control fire.
4. Progress to date of control action.
5. Routes into fire lines, marking these if requested.
6. Location of possible future camp sites.
7. Location of sources of water for camping, and control use.
8. Location of possible airplane dropping bases where needed.

9. Location of sections of lines where trailbuilders, Bosworth trenchers or tankers and similar equipment can be used to advantage in line construction, holding or mop-up.

Similar service is needed by the fire boss during the entire progress of big fires and should be rendered by special scouting forces continuously.

SCOUTING

PRICE INCURRED FOR FAILURE TO SCOUT FEASIBLE LINE LOCATION

Problem 1

USE FIGURE 41

Conditions

Region: West side, Zone 1.

Time of year: Late June.

Time of day when difficulties encountered: 4:00 P.M.

Size of fire when difficulties encountered: 310 ac.

Perimeter of fire when difficulties encountered: 300 ch.

History to date: Fire started at point (x) on river at 10:00 A.M. and by 4:00 P.M. had attained area as shown by solid white line. The fire was attacked shortly after it started by some nearby miners who failed to effect control. The fire boss arrived at point D on the road at 11:00 A.M.

The fire appeared to be spreading slowly from what the fire boss could see and had apparently made its initial run. The canyon was filled with smoke. He was accompanied by a guard who knew the country and who was capable of scouting. This man was equipped with an S radiophone and assigned the job of scouting the east flank of fire to determine the control line location on the sector. The boss scouted ridge C-D himself in advance of the arrival of additional control forces which were to report at point D around noon.

About noon the scout from point B on the river radioed the fire boss where the east flank of the fire was burning and that ridge C-B would be satisfactory for control purposes; that it would be necessary to construct and fire out this ridge line by 2:00 P.M.; that back-firing equipment would be needed; that the general character of cover was timber on the upper slope and brush on the lower slope; that the proportion of cutting to scraping tools should be 1 to 2; that there were no snags; that no water was available along ridge.

The fire boss advised the scout what he expected of him and made his plans for line C-B on the basis of the scout's report. He took action on line C-D on the basis of his own knowledge.

Lacking any information except general knowledge of the country west of the fire after consultation with a local man who claimed to

know the country the fire boss decided to run his west line down canyon D-A to the river. The canyon looked promising at the top.

At 3:40 P.M., not hearing anything from the sector boss in charge of line D-A, he sent out a messenger and learned that the crew had found some barriers in the canyon that had stopped their progress and the fire had not only crossed this canyon but was well established on the west slope of ridge H-A. Revision of plans to control west side were then necessary.

Current weather: Wind up canyon, 4 mi. per hour; relative humidity, 24%; fuel moisture, 5%. No material change in prospect.

Elevation: River 1,700'; point D 4,000'.

Topography: Relatively even along upper plateau breaking abruptly to very steep side slopes into river canyon. Canyons very difficult of access. Cliffs and bluffs common.

Rate of spread types: Scattered ponderosa pine and dense brush on plateau with light to heavy manzanita on canyon slopes.

Barriers: River is good barrier on north. Scattered cliffs also serve as barriers.

Waters available: River only.

Manpower and equipment: Ample.

Roads: Along rim only.

Solution Required

Reasons for the fire boss' failure to control the fire at smaller area and more promptly?

Acceptable Solution

The fire boss did not have sufficient information on which to base his decision to locate a control line along canyon D-A. Consequently the time that was lost in this canyon did not permit him sufficient time to utilize ridge H-A, the key location for the west flank line for several miles down the river.

Failure to obtain information on line location on the west flank of the fire was the chief reason that this fire burned a large area, since control would have been a simple matter if key ridge H-A had been used in place of inaccessible canyon D-A. Too much dependence should not be placed on local men's alleged knowledge, which often proves to be inaccurate.

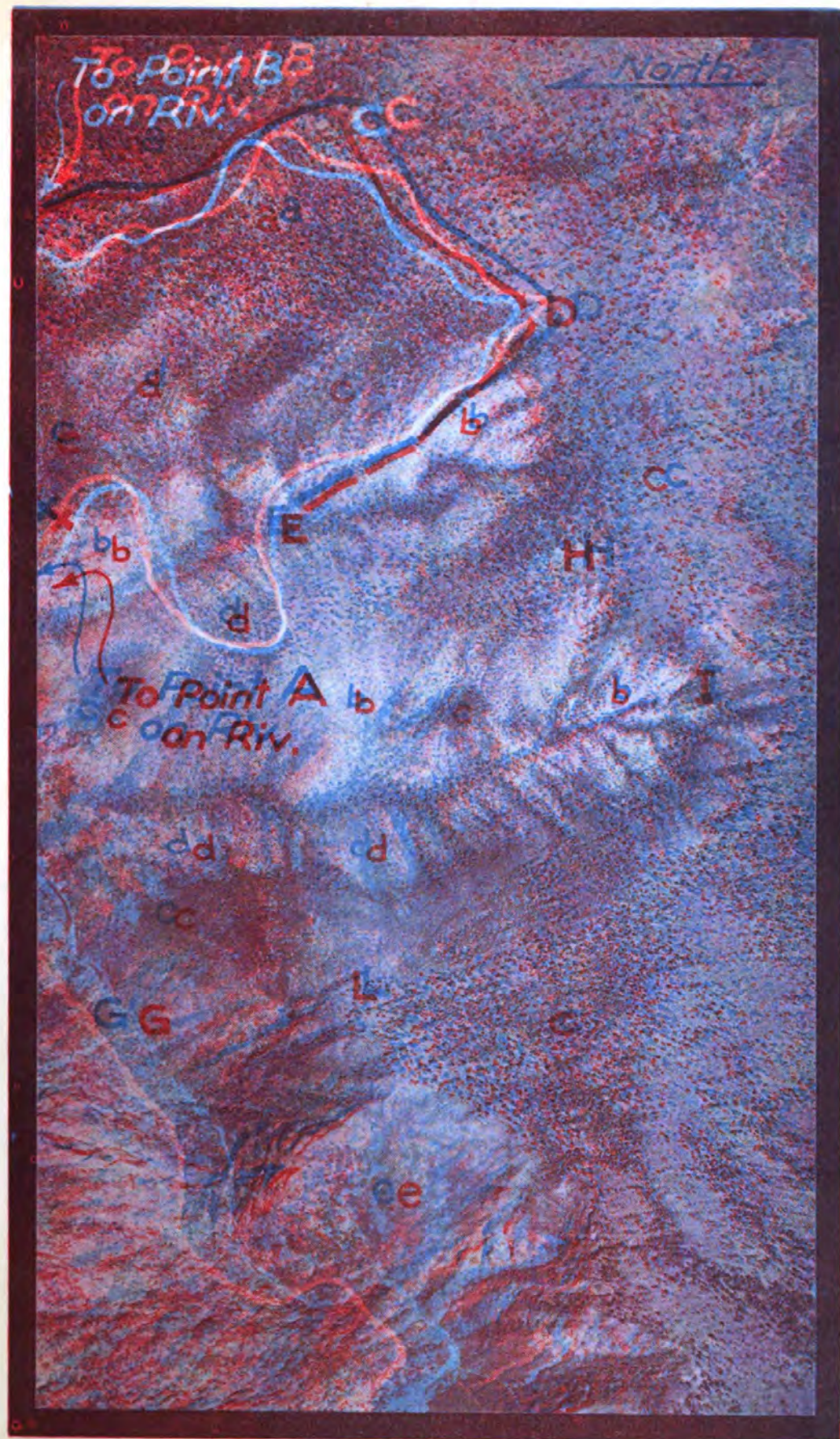
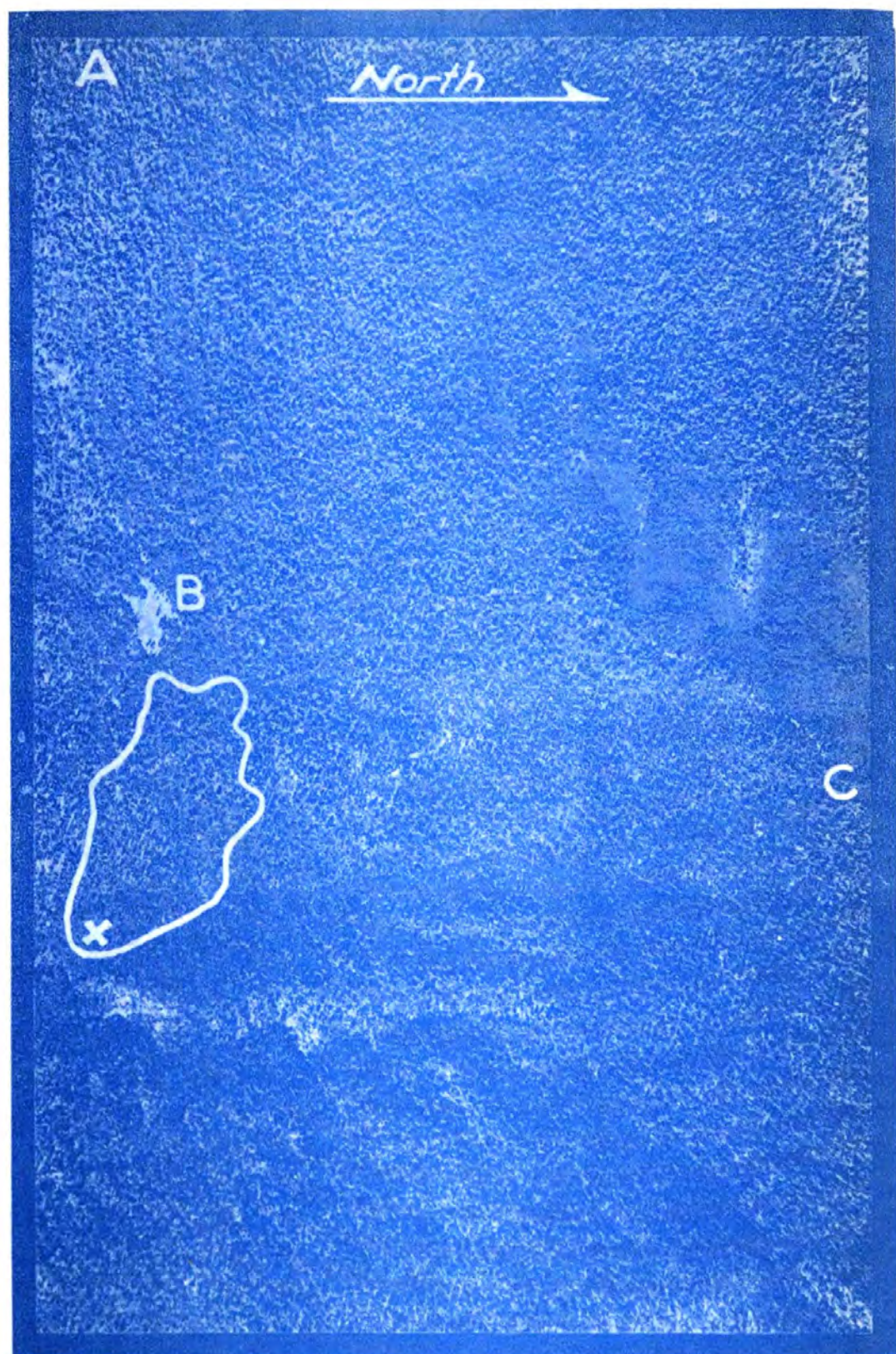


Fig. 41



Fig. 41



Scale $2'' = 1 \text{ mi.}$

Fig. 42



Fig. 42

Scale $2'' = 1 \text{ mi.}$

FIRE CAMP LOCATION

Foreword

Presence of water, accessibility by road, safety, suitability of ground for dropping supplies and for availability of airplanes and camp, ready availability of pack stock commonly control location of fire camps. One or another of these limiting factors often result in placing camps farther than absolutely necessary from the fire line. Hence: (1) long climbs to or from camp, (2) shortened effective working hours on the line, (3) reduced output because of fatigue, and (4) holding men on the line rather than sending them to camp because something might happen and camp is far away.

The problems illustrate common situations met in practice.

FIRE CAMP LOCATION

THE FACTOR OF SAFETY IN SELECTING THE LOCATION FOR FIRE CAMPS

Problem 1

USE FIGURE 42

Conditions

Region: West side, Zone 1.

Time of year: Mid-August.

Time of day when planning begins: 3:00 P.M.

Size of fire when planning begins: 90 ac.

Perimeter of fire when planning begins: 160 ch.

History of fire: Fire started at point (x) at 1:00 P.M. and by 3:00 P.M. had spread in a northwesterly direction 60 chains. It had approached the only camp site near the fire where water was available, a small, grass-covered area at B.

Current weather: East to southeast wind, 10 mi. per hour; relative humidity, 15%; fuel moisture, 3.5%. No change predicted.

Water available: At point B.

Roads: Road from C to B to A, thence on to the west.

Solution Required

Where should the fire camp be located and why?

Acceptable Solution

1. First locate dry fire camp on road in small opening at point A, hauling men to fire. Camp at A is not in the lead of the fire, making it possible to place camp at this location without danger to the men who are resting or to the equipment. It is on road with nearest open area and road facilities where camp may now be located with adequate safety.
2. As soon as area B is decided to be safe, move camp to this location because B is closer to fire edge and water is available.
3. Even if there were no water at B the camp should be moved from A to B since B will be close to fire. Water can be hauled in mobile tanks for camp water supply more easily than men can hike or be hauled from a camp at some distance from the fire edge.

CAMP LOCATION

LOCATING CLOSE TO CENTER OF EXPECTED CONTROL LINES

Problem 2

USE FIGURE 43

Conditions

Region: West side, Zone 1.

Time of year: August.

Time of day when planning begins: 2:00 P.M.

Size of fire when planning begins: 18 ac.

Perimeter of fire when planning begins: 65 ch.

History of fire: Discovered by lookout at 1:55 P.M. and reported to Ranger at 2:00 P.M., when planning started. Probable origin of fire 11:55 A.M.

Weather: N. wind, 15 mi. per hour; relative humidity, 15%; fuel moisture, 4%. Weather expected to be constant until 8:00 P.M. when wind will decrease to 8 mi. per hour with direction "variable."

Topography: Steep slopes B to C; medium slopes south of C.

Rate of spread types: Timber, medium reproduction and brush. Rate of perimeter spread on 40% slope with 8 mi. wind = 30 ch. per hour.

Barriers: None.

Water available: At A.

Manpower available: All men ordered can be on fire line at 4:00 P.M.; no men available before 4:00 P.M. due to other fires.

Equipment available: All necessary.

Roads available: Lower road E crosses lower or north end of fire. Middle road F crosses fire about 20 ch. south of north end of fire. Upper road G about 40 ch. south of north or lower end of fire.

Values: Uniform.

Solution Required

1. Location and size of fire when planning is started (2:00 P.M.).
2. Location and size of fire when full attack force is available (4:00 P.M.).
3. Location of fire camp or camps, with reasons.

Acceptable Solution

1. Between 11:55 A.M. and 2:00 P.M. fire moved south up slope approximately 28 ch. linear distance. At 2:00 P.M. the perimeter of the fire was as shown by smaller area on figure 43 with a perimeter of approximately 65 ch. (Line C).

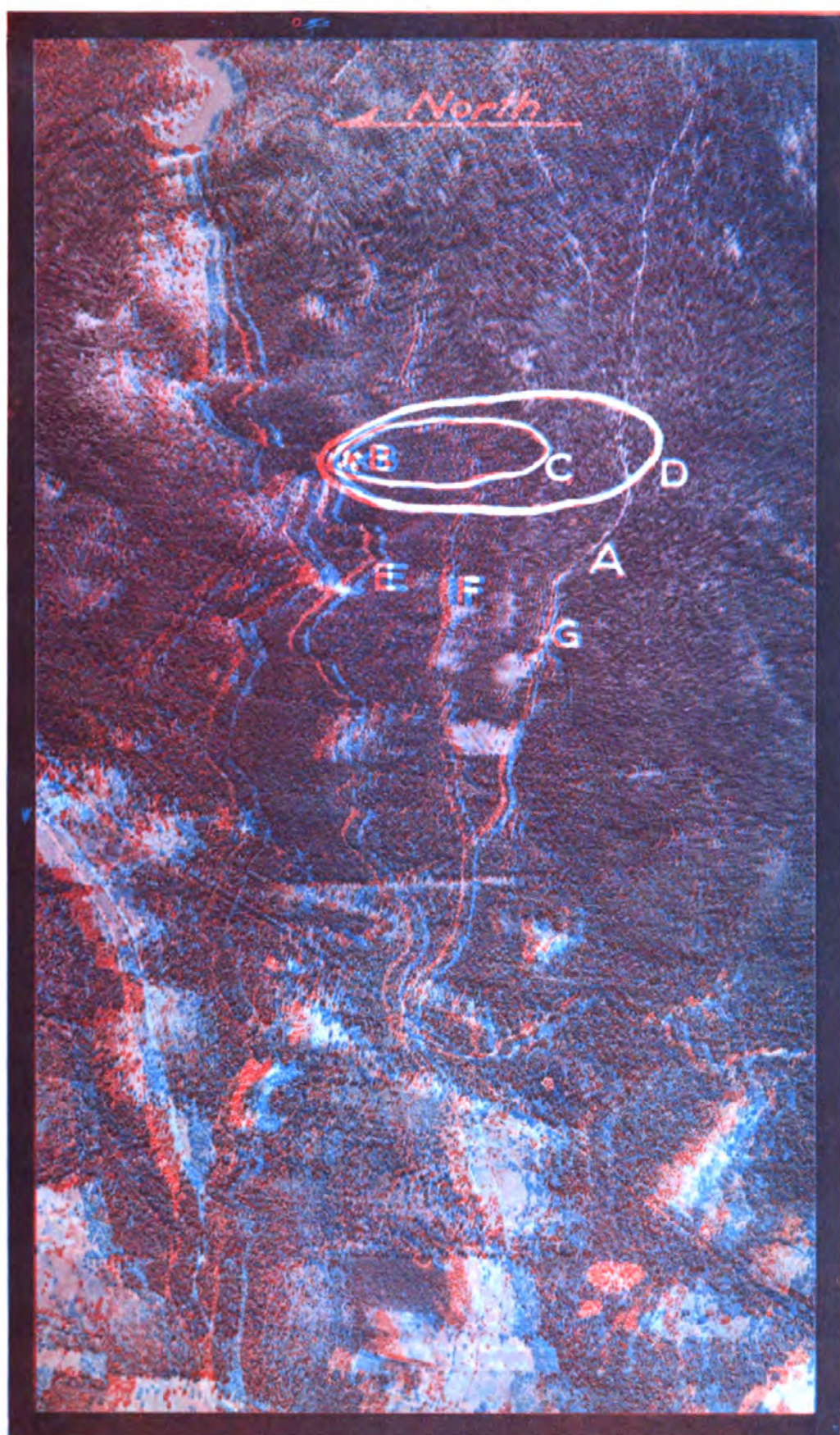


Fig. 43

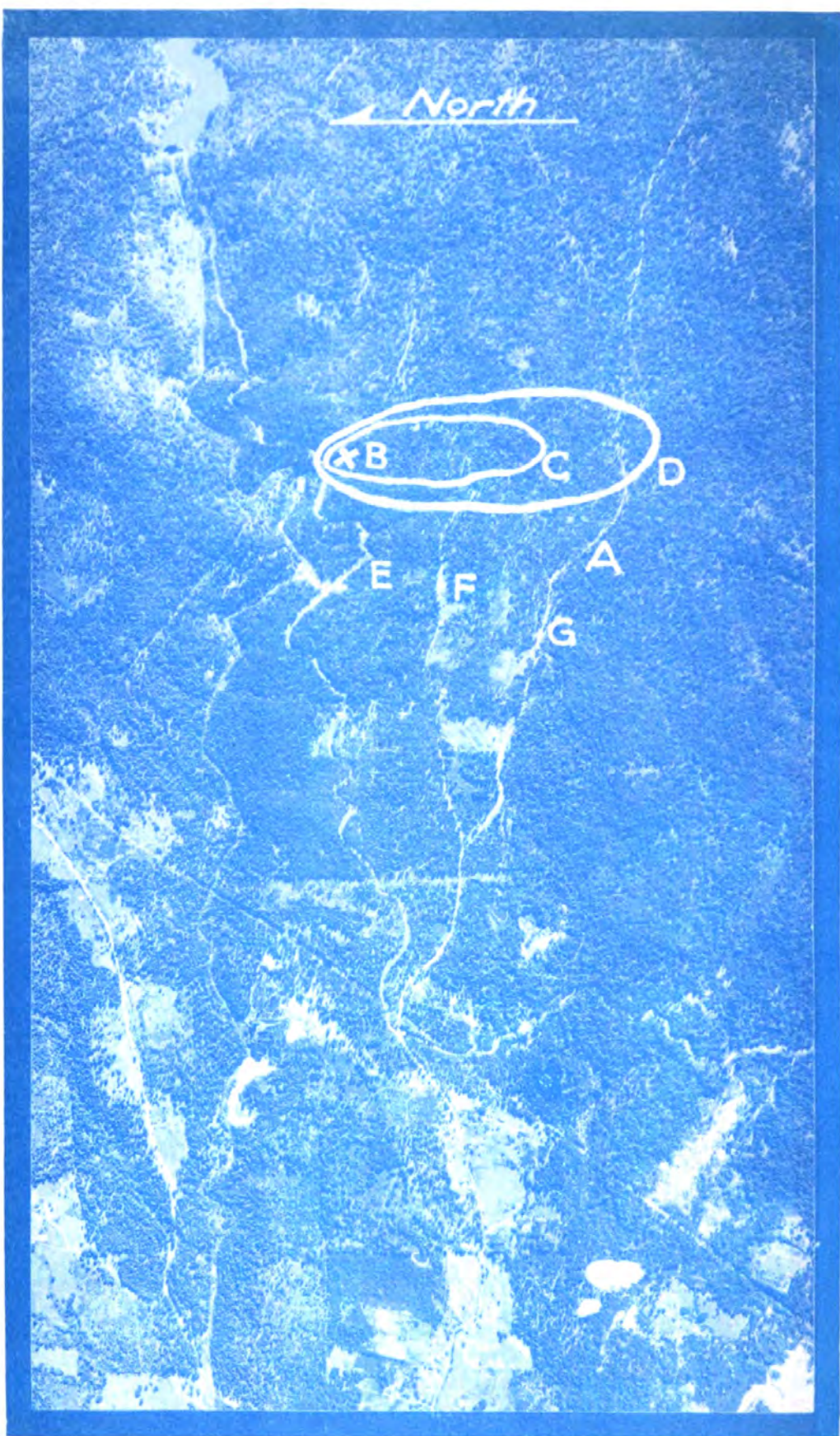


Fig. 42

Scale 3" = 1 mi

2. Between 2:00 P.M. and 4:00 P.M. the forward progress of the fire will slow down to 7 ch. per hour due to the change in slope. Thus it will move forward 14 additional ch., or 42 ch. from point of origin. The rate of perimeter increase likewise lessens to 15 ch. per hour. At 4:00 P.M. fire will have a perimeter of 65 ch. + 30 ch. or 95 ch. (See larger area enclosed for estimated location of fire at 4:00 P.M.)
3. One fire camp will be sufficient to handle the fire crew. It should be located at the west side of and as close as possible to the fire line on road G. This will place the camp approximately 40 ch. from the north end of the fire, 15 ch. from the south end of the burned area and about 20 ch. from the east side of the fire. The selected location will permit crews to go down hill to reach the furthest distant fire line. Location almost adjacent to the fire is desirable and safe because the camp is on a road, where even with a change in wind the men and equipment may be moved to safety via the road within a relatively few minutes. The fire boss can transport men by truck to north end of fire west on road G from Camp A and back along roads F and E to fire edge.

CAMP LOCATION

USING ALL AVAILABLE MEANS TO SERVICE CAMP SO IT CAN BE
LOCATED CLOSE TO FIRE

Problem 3

USE FIGURE 44

Conditions

Region: West side, Zone 2.

Time of year: August.

Time of day when planning begins: 9:30 A.M.

Size of fire when planning begins: 50 ac.

Perimeter of fire when planning begins: 130 ch.

History of fire: Fire started about 7:00 A.M. at point (x).

Weather: NW. wind, 15 mi. per hour; relative humidity, 25%; fuel moisture, 5%. No major change in wind anticipated.

Elevation: Point C, 6,000'. Fire area from 6,000' at starting point to 7,000' on high ridge.

Topography: Steep (50-60%) on fire area.

Rate of spread types: Open timber, medium reproduction and brush.

Water available: None nearer than at road in valley to northeast of fire.

Manpower available: As needed.

Roads and trails: Nearest road is in valley at point C, to NE., at distance of one mile and 1,000' below highest, or ridge, portion of fire.

Solution Required

Locate camp for fire suppression forces and give major reasons for decision.

Acceptable Solution

Fire camp should be located on ridge at point A about 10 ch. along ridge from fire line. This location will permit men to reach any portion of present fire line with minimum distance and effort. Supplies and water can be furnished by airplane dropping. If camp is located at road the crews would have to walk cross-country one mile each way to fire, climbing about 1,000' in elevation each day. As a result the men would use 1 to 2 hours each day walking and would be badly fatigued when reaching fire, as well as shorten their work time that much.

Supplemental

The same principle of locating camp close to fire lines with water and food packed in or dropped to camps to lessen the physical drain and losses of time on the part of the men is vital in fire control planning.

POINTS TO CONSIDER IN FIRE CAMP LOCATION

1. Seek accessibility to fire line to minimize drain on men in going to and from such fire lines.
2. Watch for safety to men and equipment; lack of likelihood of being burned out.
3. Seek ease of servicing by trucks, pack stock or airplanes.
4. Presence of water supply is important but can be dropped to medium size camps.
5. Camp must be large enough to handle forces and equipment.

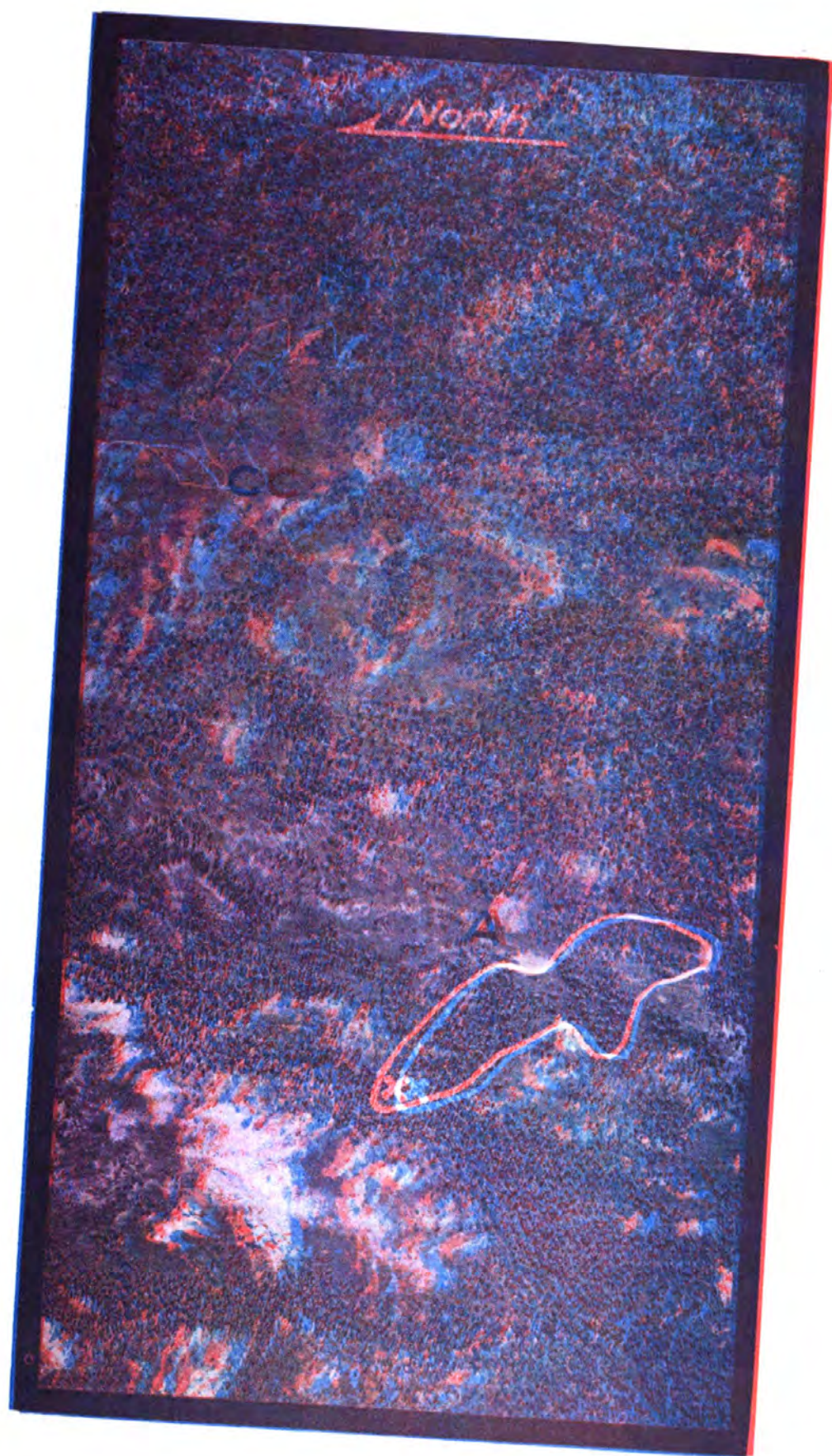


Fig. 44. Coastal region of the Gulf of Mexico.

North

C

A

X

APPRAISAL OF FORCES NEEDED

Foreword

The appraisal of forces needed has been primarily a matter of individual judgment and thus highly variable for a given problem, depending largely on the experience of the man concerned or on his optimism or pessimism.

The new information given here cannot wholly supplant judgment but it does afford a sounder basis for judgment than has heretofore existed, or than is likely to be available even to the most experienced individual.

More work is clearly needed to further strengthen this start toward a sound basis, particularly on the effect of fatigue, quality and organization of labor, and similar unknowns on line production. Till this information is obtained, study and use of the method and values given here are desirable.

APPRAISAL OF FORCES NEEDED

Line Construction Types and Experimental Rates of Line Construction

Experimental tests of rate of line construction on most of the Forests made in 1938 and 1939 have been grouped into 15 line construction types (Table 6, Col. 1). The *average rate* of line construction in each type in sq. ft. of line per man-hour is in Col. 7. The average ch. per man-hour for a standard line cut to 5 ft. and scraped to 2½ ft. is in Col. 8. The highest rate of line production, in grass (Type 1) and in closed woodland (Type 3a), is over 1000 sq. ft. and over 3 ch. per man-hour. The lowest rate, in the heaviest mixed brush (Type 14), is less than 1/10 as large or 0.3 ch. and 99 sq. ft. For several common types, such as heavy duff and slash, no tests are available and no type or production rates are given.

In all tests, seasoned crews were used for periods of 1 or 2 hours' work only.

Actual or Normal Line Width in Types

Actual width of line constructed, both as to cutting and scraping, varies from type to type and is rarely the same as that adopted as standard in the line construction tests. The usual or "normal" actual widths are in Table 6, Cols. 3 and 4.

Normal Production Rates by Types

Combining the test rates of line production with the normal or average widths results in normal production rates by type (Table 6, Col. 11). The highest rate is 6.2 ch. per man-hour in Type 3a. The lowest is .3 ch., or 1/20 at great, in Type 14.

These figures represent production by seasoned men working for only 1 or 2 hours, equipped with correct hand tools in good condition and working in the daytime.

Hand Tools in Different Types

The tests showed that in the lighter types a crew was most effective with 25% cutting and 75% scraping tools. In heavy types the proportions were reversed, and in intermediate types a graduated change from few to more cutting tools was found (Table 6, Cols. 5 and 6).

TABLE 6
LINE CONSTRUCTION TYPES
CALCULATING TABLE FOR MANPOWER REQUIREMENTS

Column 1	2	3	4	5	6	7	8	9	10	11	12
TYPE	No.	Normal Total width clear (feet)	Normal width to mineral soil (feet)	Percent cutting	Percent scrapping	Sq. ft. per man-hour	Chains per man-hour for 5' x 2½' line	Men per 10 chains in one hour	Relation Normal to Standard (Test Crew)	Normal chains per man-hour	Men per 10 chains in one hour
Grass.....	1	2	2	--	100	1060	3.2	3—5	80%	4.0	3—5
Grass-scattered brush.....	2	2	2	-25	75+	825	2.5	3—5	70%	3.6	3—5
Closed timber-needles, little chopping.....	3	2½	1½	-25	75+	891	2.7	3—5	57%	4.7	3—5
Closed woodland and little chopping.....	3a	2	1½	-25	75+	1120	3.4	3—5	55%	6.2	3—5
Bear Clover.....	4	3	1½	45	55	730	2.2	6—10	60%	3.7	3—5
Open manzanita—patchy brush in cutovers—no slash.....	5	3	1½	45	55	630	1.6	6—10	60%	2.7	3—5
Timber—medium reproduction and brush	6	5	2½	45	55	450	1.4	6—10	100%	1.4	6—10
Light to medium chamise—southern California.....	7	2½	1½	45	55	480	1.5	6—10	55%	2.7	3—5
Brush mixtures with sage—Southern California.....	8	4	2	45	55	350	1.1	6—10	80%	1.4	6—10
Medium brush cutovers or timber burn.....	9	5	2	45	55	360	1.1	6—10	89%	1.2	6—10
Mixed DF-WF with brush and reproduction.....	10	3	1½	60	40	230	0.7	11—15	60%	1.1	6—10
Medium brush with oak—Southern California.....	11	5	2	70	30	198	0.6	16—20	94%	0.7	11—15
Heavy pure manzanita, chamise, buck brush.....	12	5	1½	70	30	214	0.65	16—20	88%	0.7	11—15
Heavy mixed brush.....	13	6	2	75	25	165	0.50	16—20	110%	0.4	21—30
Heaviest mixed brush.....	14	6	2	75	25	99	0.30	31+	110%	0.3	31+

*Line Construction Hourly Rates
with Crew of Fixed Size.*

*Reductions - 10 minutes rest per hour = 15%
10% Fatigue reductions.*

Chart B

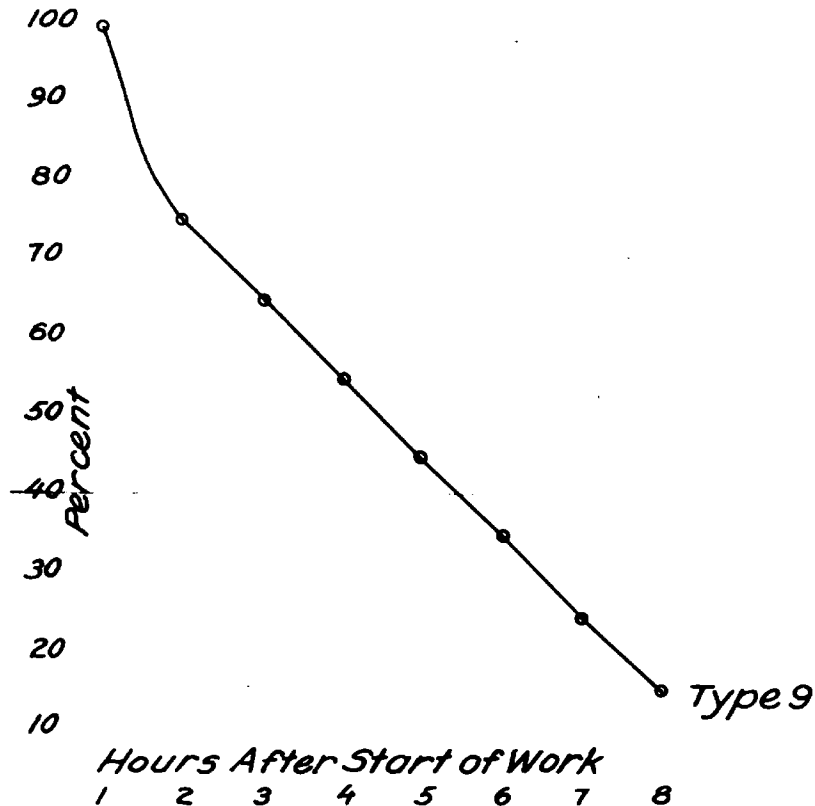
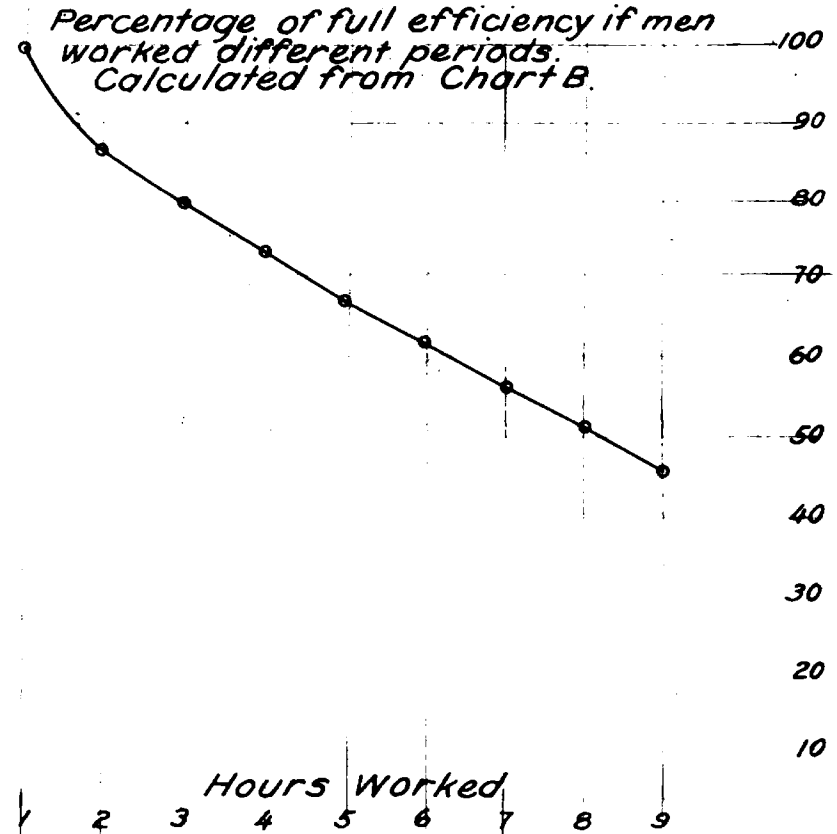


Chart C



Reduction in Line Output From Fatigue

The experimental tests showed that during the second hour of work production was 10% less than during the first hour, even after a 10-minute rest period at the beginning of the second hour. The expected output of the second hour is thus 25% less than for the first hour (15% loss for rest plus 10% for fatigue).

It has been assumed—no authentic experimental data exist—a 10% fatigue loss occurs in each successive hour after the first.

The normal line construction output by types for work periods of 1-8 hours is shown in Table 7. The total for an 8-hour shift is slightly more than twice that for a 2-hour shift (Table 7 and Charts B & C).

TABLE 7
CALCULATING TABLES—CONSTRUCTION ONLY

Type	Normal Ch. Per Man-Hr.	Number of Chains 10 Men Will Build in							
		1 100%	2 87.5%	3 80%	4 74%	5 68%	6 63%	7 57%	8 Hours 52%
1	4.0	40	70	96	118	136	151	160	166
2	3.6	36	63	86	107	122	136	144	150
3	4.7	47	82	113	139	160	178	188	192
3-a	6.2	62	109	149	184	211	234	247	258
4	3.7	37	65	89	110	126	140	148	154
5	2.7	27	47	65	80	92	102	108	112
6	1.4	14	24	34	41	48	53	56	58
7	2.7	27	47	65	80	92	102	108	112
8	1.4	14	24	34	41	48	53	56	58
9	1.2	12	21	29	36	41	45	48	50
10	1.1	11	19	26	33	37	42	44	46
11	0.7	7	12	17	21	24	26	28	29
12	0.7	7	12	17	21	24	26	28	29
13	0.4	4	7	10	12	14	15	16	17
14	0.3	3	5.6	7.2	8.9	10.2	11.3	12.0	12.5

(a) From Chart C curve.

Calculation of Normal Manpower Requirements for Line Construction only

Examples of manpower requirements, line construction only, are given in Problems 1 and 2.

You may need to know either—

- In how many hours a given crew will construct a given length of line in a given type.
- How large a crew is required to construct a given length of line in a given type in a specified number of hours.

MANPOWER CALCULATIONS

Problem 1

- Type 9 (medium brush cutovers or timber burn).
- Chains to build 100.
- Construction crew 40 men (no holding crew).
- Solution required—hours to construct.

Acceptable Solution

1. First hour rate per man 1.2 ch. (Table 6, Col. 10).
2. First hour production $40 \times 1.2 = 48$ ch.
3. Second hour rate per man $75\% \times 1.2 = .9$ ch. (Chart B).
4. Second hour production $40 \times .9 = 36$ ch.
Total first and second hours 84 ch. (See Type 9, 2-hour Col. Table 7, which, if this table is used, will give same ans. $21 \times 4 = 84$ ch.)
5. Third hour rate per man $65\% \times 1.2 = .8$ ch. (Chart B).
6. Third hour production $40 \times .8 = 32$ ch.
7. About $2\frac{1}{2}$ hours to complete 100 ch.

MANPOWER CALCULATIONS

Problem 2

Construction only, crew required to build line in Problem 1 in 4 hours.

Acceptable Solution

1. Average production rate for 4-hour shift is 75% of first hour rate (Chart C).
2. First hour rate 1.2 ch. per man.
3. Average $75\% \times 1.2 = .9$ ch. per man.
4. Total for 4 hours $4 \times .9 = 3.6$ ch. per man.
5. Men required $100 \div 3.6 = 28$ men, or *using Table 7*, 10 men will construct 36 ch. in 4 hrs.— 100 ch. to build—thus $(100 \div 36) \times 10 = 28$ men.

Manpower Requirements for Line-Holding

In all the types except pure grass and when the line is burned out as it is built, it is necessary to leave men behind the construction crew to hold the line. This operation is here considered as distinct from line construction, backfiring, mop-up, and patrol.

Estimates:

1. Number of men needed per 10 chains of constructed and fire line, and
2. Number of hours that such forces are needed on a particular line are given in Table 8.

TABLE 8
LINE HOLDING FOR LINE CONSTRUCTION TYPES
CALCULATING TABLE FOR MANPOWER REQUIREMENTS

Column 1 <i>Type</i>	2 <i>Men Per 10 Chains</i>	3 <i>Time for Holding Hours</i>
1	0	0
2	$\frac{1}{2}$	$\frac{1}{2}$
3	1	$1\frac{1}{2}$
3-a	1	1
4	2	1
5	4	3
6	3	3
7	$\frac{1}{2}$	$\frac{1}{2}$
8	1	$\frac{1}{2}$
9	8	4
10	3	1
11	6	4
12	3	1
13	8	4
14	10	4

Calculation of Line-Holding Manpower Requirements

The basis for calculations is given in Table 9. No fatigue nor rest reductions are made.

An example of calculating requirements is given in Problem 3.

TABLE 9
CALCULATING TABLE—LINE HOLDING ONLY

Type	Men Per 10 Ch.	Hours Nec. for Line to be Manned	Number of Men Required for Holding Line Constructed at 10 Chains per Hour.							
			Number of Chains							
			10	20	30	40	50	60	70	80
1	0	0								
2	$\frac{1}{2}$	$\frac{1}{2}$	1	1	1	1	1	1	1	1
3	1	$1\frac{1}{2}$	1	2	2	2	2	2	2	2
3-a	1	1	1	1	1	1	1	1	1	1
4	2	1	2	2	2	2	2	2	2	2
5	4	3	4	8	12	12	12	12	12	12
6	3	3	3	6	9	9	9	9	9	9
7	$\frac{1}{2}$	$\frac{1}{2}$	1	1	1	1	1	1	1	1
8	1	$\frac{1}{2}$	1	1	1	1	1	1	1	1
9	8	4	8	16	24	32	32	32	32	32
10	3	1	3	3	3	3	3	3	3	3
11	6	4	6	12	18	24	24	24	24	24
12	3	1	3	3	3	3	3	3	3	3
13	8	4	8	16	24	32	32	32	32	32
14	10	4	10	20	30	40	40	40	40	40

MANPOWER CALCULATIONS

Problem 3

Line-holding crew required with construction crew in Problem 1.

Acceptable Solution

- | | |
|----------------------|---|
| 1. First hour | $48 \div 1.25 = 38$ men (Table 8, Col. 2) |
| 2. Second hour | $36 \div 1.25 = 29$ men |
| 3. Third hour | $16 \div 1.25 = 13$ men |
| Total for third hour | 80 men |

Calculations of Manpower Requirements for

Combination Line Construction and Line-Holding Crew by Types

The manpower in *separate* crews for construction and holding is reduced if the line holding is done by progressively dropping men off from the initial construction crew.

As a basis for calculation, it is assumed that men are dropped off at 15-minute intervals if needed. With a 10-man initial crew in light and medium types, over 10 ch. will be built in the first 15 minutes.

It is assumed that line-holding men progressively move up to new sections of line after they have been on first sections the period stated in Table 8, Col. 3.

TABLE 10

**COMBINATION CONSTRUCTION AND LINE-HOLDING CREW
AMOUNT OF FIRE LINE CONSTRUCTED AND HELD BY 100 MEN***

	<i>Hours of Work</i>								<i>Hours</i>
	1	2	3	4	5	6	7	8	
<i>Type</i>	<i>Chains of Line</i>								
1	400	700	960	1180	1360	1510	1600	1660	
2	310	543	741	922	1057	1183	1252	1301	
3	354	560	755	941	1091	1232	1315	1378	
3-a	385	617	858	1070	1248	1410	1497	1579	
4	230	357	504	638	743	848	913	965	
5	125	125	125	176	238	270	290	311	
6	111	160	194	225	268	301	321	336	
7	265	463	634	788	904	1011	1070	1110	
8	133	227	322	389	457	515	544	564	
9	62	66	69	72	93	120	134	142	
10	92	151	207	263	305	340	358	377	
11	55	79	96	106	118	130	144	151	
12	63	105	148	183	210	229	248	257	
13	34	52	66	73	82	88	95	102	
14	26	42	50	57	64	71	76	80	

*Data on construction from Table 7.
Data on holding from Table 8.

Type 9
Basic Rate 1.2 chs. per man first hour for Line Construction
8 men per 10 chs. for 4 hours for Line Holding

Chart D

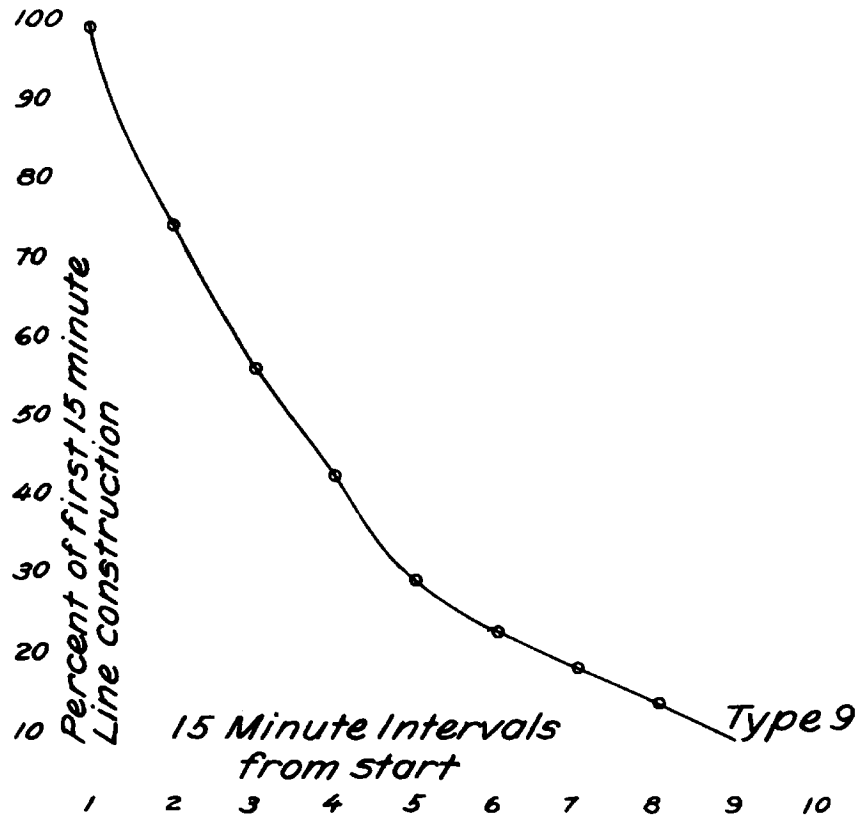
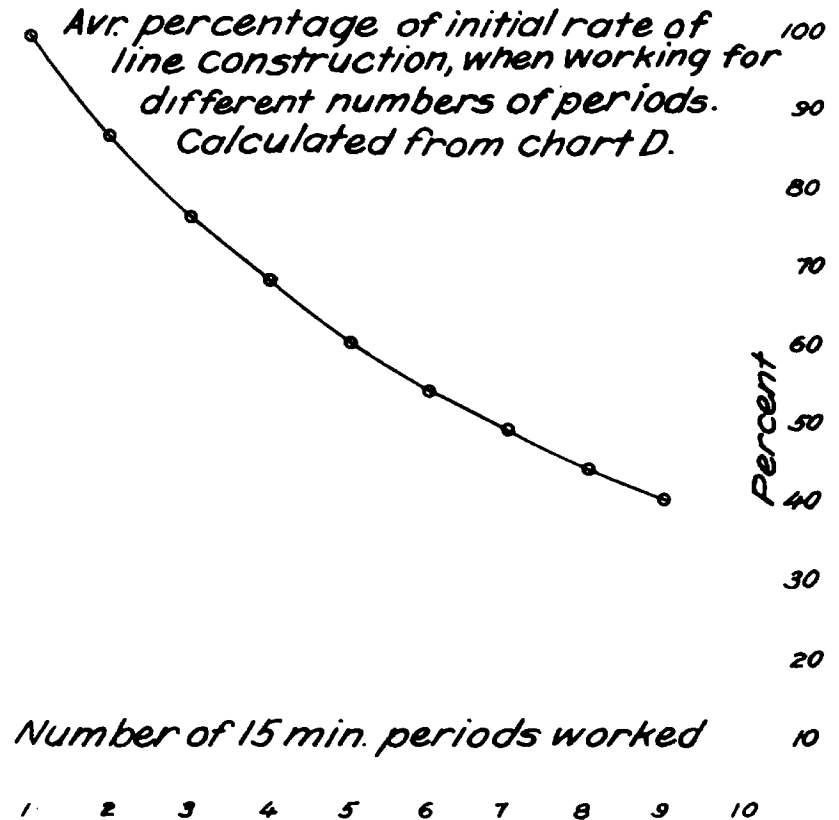


Chart E



The calculating basis for type 9 is given in Charts D and E.

Examples of calculating manpower requirements for combination construction and holding crews are given in Problems 4 and 5.

- a. When you need to know size of crew required to handle line of stated length in stated type in stated length of time.
- b. Period required for crew of stated size to handle line of stated length in stated type.

MANPOWER CALCULATIONS

Example

Problem 4

Size of initial crew required in Problem 1 for combination line building in 2 hours; line-holding men to drop from construction to holding after each 15-minute period as required.

Acceptable Solution

1. Two hours = eight 15-minute periods.
2. Average for 8 periods is 45% of initial period rate (Chart E).
3. Initial rate 1.2 ch. per man-hour or 0.3 ch. per 15-minute period.
4. Average $45\% \times .3 = .135$ ch.
5. $.135 \times 8 = 1.08$ ch.
6. $100 \div 1.08 = 92$ men to construct and hold line.

MANPOWER CALCULATIONS

Example

Problem 5

Period required for initial crew of 100 men to construct and hold line under conditions of Problem 4.

Acceptable Solution

- a. Average required line construction per man $100 \div 100 = 1.0$ ch.
- b. Initial rate of 0.3 ch. per period.

*Cumulative Total
Chains Built*

- | | |
|---|------|
| 1. First period rate 0.3 ch. (Table A, Col. 10) | |
| 2. First period production $100 \times .3 = 30$ | 30 |
| 3. Second period rate 75% of first (Chart D) | |
| 4. Second period production $75 \times .3 = 22.5$ | 52.5 |
| $(.75 \times 100) \times .3 = 22.5$ | |
| 5. Third period rate 57% of first | |
| 6. Third period production $57\% \times .3 = 17.1$ | 69.6 |
| 7. Fourth period rate 43% of first | |
| 8. Fourth period production $43\% \times .3 = 12.9$ | 82.5 |

9. Fifth period rate $30\% \times .225$ (Chart B deduct for rest and fatigue)
10. Fifth period production $30 \times .225 = 6.8$ 89.3
11. Sixth period rate $24\% \times .27$
12. Sixth period production $24 \times .27$ (10% deduction for fatigue) = 6.5 95.8
13. Seventh period rate $18\% \times .27$
14. Seventh period production $18 \times .27 = 5$ 100.8
15. Approximately $1\frac{3}{4}$ hours required

Legitimate Reductions From Basic Rates of Line Production and Holding

These are legitimate *increases* in manpower requirements.

The following are known to exist, but there is no measure of their importance:

1. For night work.
2. Quality of men on crew.
3. Crew organization (not worked as crew before).
4. Crew leaders high quality.
5. Very steep, rough country.
6. Very rocky ground.
7. Weather very hot.

Tractor Production Figures

Existing authentic records to date show:

1. *Heavy machines* (75's, RD-7 and RD-8) do 17,700 sq. ft. per tractor hour. In light cover types average line width $1/10$ ch. (6.6'). Thus $40 \div$ linear chains of line (40×435) per hour.
2. *Heavy machines* (same as under 1) do 4,300 sq. ft. per tractor hour in heavy cover types. Thus 10 linear ch. of line per hour.
3. *Medium machines* (50 & 55) do 10,700 sq. ft. per tractor hour in light cover types. Thus 25 linear ch. per hour.
4. *Medium machines* do 4,900 sq. ft. per tractor hour in medium types. Thus $11 \div$ ch. per hour.
5. *Light machines* (35's) do 3,700 sq. ft. per tractor hour in medium cover types. Thus $8\frac{1}{2}$ linear ch. per hour.
6. *Light machines* in light cover (pine needles) based on one case do 56,000 sq. ft. per tractor hour. Thus 130 linear ch. per tractor hour.

TABLE 11
RATIO—MACHINES TO MANPOWER FOR LINE CONSTRUCTION

WORK TYPES	AVERAGE NORMAL CHAINS PER MAN-HOUR	HEAVY TRACTOR RATE	MEN PER MACHINES	MEDIUM MACHINE	MEN PER MACHINE	LIGHT MACHINE	MEN PER MACHINE
Light.....	4.2	41 ch.	10	25 ch.	6	-----	-----
Medium..	2.0	24* ch.	12	11 ch.	6	8.5 ch.	4
Heavy....	0.65	10 ch.	15	6* ch.	10	-----	-----

* Interpolated.

Tractor line is 6.6' wide.

Hand line in light types averages 2.2' wide.

Hand line in medium types averages 3.9' wide.

Hand line in heavy types averages 5.0' wide.

POINTS TO CONSIDER

1. The appraisal needs first of all to be broken down into the separate phases of line construction and line holding.
2. The number of men required per 10 ch. in each step varies greatly from type to type.
3. The values for most of the common types, as determined by experiment, are, being for fresh seasoned men, an approximate maximum.
4. Reductions from the production figures are justified to the degree that available crews fall below top quality, or conditions of work exceed average difficulty.
5. The preliminary data on relative output of men and machines furnish a provisional basis for calculation.
6. Study and use will start the orderly process of more accurate appraisal of needs on the line.

CHANGES IN WEATHER DURING CONTROL

Foreword

With the constantly improving facilities that are being developed in connection with fire weather forecasting it is becoming increasingly easy for the fire boss to know what changes in weather are impending and to take these changes into consideration in planning his control measures.

Prompt action to take advantage of changes in an element such as wind velocity, which has a vital bearing on rates and direction of fire spread, is one essential in competent fire control planning. Conversely, quick recognition and swift action to put into effect measures needed to meet weather changes are essential to the success of fire control planning.

Skillful evaluation of the effect of changes in weather conditions on fire behavior is a field in which training will be fruitful. It will mean more certain jobs of suppression, smaller acreage and lower costs.

CHANGES IN WEATHER

WEATHER CHANGES FOR WORSE AFTER ATTACK NECESSITATES CHANGE IN PLANS

Problem 1

USE FIGURE 45

Conditions

Region: Northwest coast.

Time of year: July.

Time of day when planning begins: 2:00 P.M.

Size of fire when planning begins: 5 ac. (small area enclosed by white line).

Perimeter of fire when planning begins: 25 ch.

History: Fire started at point (x) 1:00 P.M. Reported 2:00 P.M.

Weather: W. wind up slope, 5 mi. per hour; relative humidity, 20%; fuel moisture, 4.5%. No change in weather predicted. (Actually, however, wind changes to 20 mi. per hour at 2:30 P.M.)

Elevation: River, 2,500'; ridge, point C 3,000', point F 2,800'.

Topography: 40% slope from river to point C. Reverse slope point C to point F 30%.

Rate of spread types: South of point C and along ridge to the west light grass, open timber. Rest of area timber, medium reproduction and brush, except few patches of grass. With 5 mi. wind and 40% slope linear rate of spread $7\frac{1}{2}$ ch. per hour. With 20 mi. wind and 40% slope linear spread 26 ch. per hour. With 20 mi. wind and 30% reverse slope linear spread 8 ch. per hour.

Resistance to line construction: RD-7 trailbuilder will construct 24 ch. of line per hour in heaviest type encountered. Men will construct 3 ch. per hour in light cover, 1.4 ch. per hour in heavier timber.



Barriers: River to west of fire line forms satisfactory barrier. Road on line F-G forms line which can be used for backfiring if needed.

Water available: In river only.

Manpower available: As needed within $\frac{1}{2}$ hr. after call.

Equipment available: 1 RD-7 trailbuilder within $\frac{1}{2}$ hr. after call.

Roads and trails: Road on line F-G.

Solution Required

Develop plan of attack for control of fire with:

1. Conditions as of 2:00 P.M.
2. Conditions as of 2:30 P.M. when wind raised from 5 to 20 mi. per hour.

Acceptable Solution

1. *Plan of attack as of 2:00 P.M.*

Head of fire is advancing toward line B-C at the rate of $7\frac{1}{2}$ ch. per hour. Fire boss calculates fire will reach this line which is 15 ch. away in two hours or at 4:00 P.M. He computes line can be built and backfired around the head of the fire from B to C, a total length of 30 ch. with trailbuilder and 20 men within an hour. Two additional crews of 20 men each will be needed to carry the line and backfire this from B and C to the River. This can be done also within an hour. Five men more will be needed to patrol the river to be sure nothing happens there. Men and trailbuilder must be at point C ready to go to work not later than 2:30 P.M.

2. *Plan Change when Wind Rises to 20 mi. per hour at 2:30 P.M.*

When wind accelerated so rapidly at 2:30 P.M. the fire picked up and started to run at the rapid rate of 26 ch. per hour toward line B-C on which men were about to start work. This would put the head of the fire across the divide shortly after 3:00 P.M. The fire boss was in close touch with the situation and pulled the men off line B-C, on which time to do little work had been available and luckily on which no backfire had yet been set and removed them to point F.

Plan (1) was dropped completely and the trailbuilder and the major part of the manpower started at point F to build and backfire a line from points F to E. Another crew backfired the road from F to G and thence carried the line into the River at H. The fire boss' computation showed that there was plenty of time to complete this plan, even in the face of the heavy wind, since with the reverse slope the rate of spread was not rapid enough to cause fire to reach the line near F before 4:30 P.M.

See large area enclosed by white line for estimated location of fire at 4:00 P.M.

Supplemental

In the original control plan fire boss considered line location E-F-H as a possibility if the other plan failed so had a definite alternative plan to fall back on when first effort was unsuccessful.

CHANGES IN WEATHER

WEATHER CHANGES FOR BETTER AFTER ATTACK PLAN INITIATED NECESSITATES CHANGE IN SUPPRESSION PLANS

Problem 2

USE FIGURE 46

Conditions

Region: West side, Zone 1.

Time of year: Late September.

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: 26 ac. (28 ch. long).

Perimeter of fire when planning begins: 70 ch.

History: Fire started at point (x) at 4:00 P.M.

Weather: SW. wind, 15 mi. per hour; relative humidity, 15%; fuel moisture, 4%. Weather predicted: no material change except usual nightly fluctuation and reduction in wind velocity to 5 mi. per hour.

Elevation: Point (x) = 2,000', top of break C-M = 3,000', along trail G-H = 3,500'.

Topography: Point (x) to C-M = 60% slope, top of break C-M to trail G-H = 25% slope.

Rate of spread types: Timber, medium reproduction and brush. Linear rate of fire spread from point (x) to top of break C-M with 60% slope and 15 mi. wind = 28 ch. per hour. Linear spread with same weather from break C-M to ridge G-H = 14 ch. per hour.

Barriers: River—satisfactory fire line.

Water available: In river only.

Manpower available: 50 men due to arrive at point F by 6:00 P.M. Additional men as needed can be on fire line by 8:00 P.M.

Equipment available: RD-7 trailbuilder available for use on fire line point F by 6:00 P.M.

Roads and trails: Main road at point F 50 ch. northwest of fire. Trail along line F-G-H.

Solution Required

1. Determine plan of attack based on weather conditions as of 5:00 P.M.
2. Change plan to fit change in wind velocity to 15 mi. per hour down canyon at 6:00 P.M.

Acceptable Solution

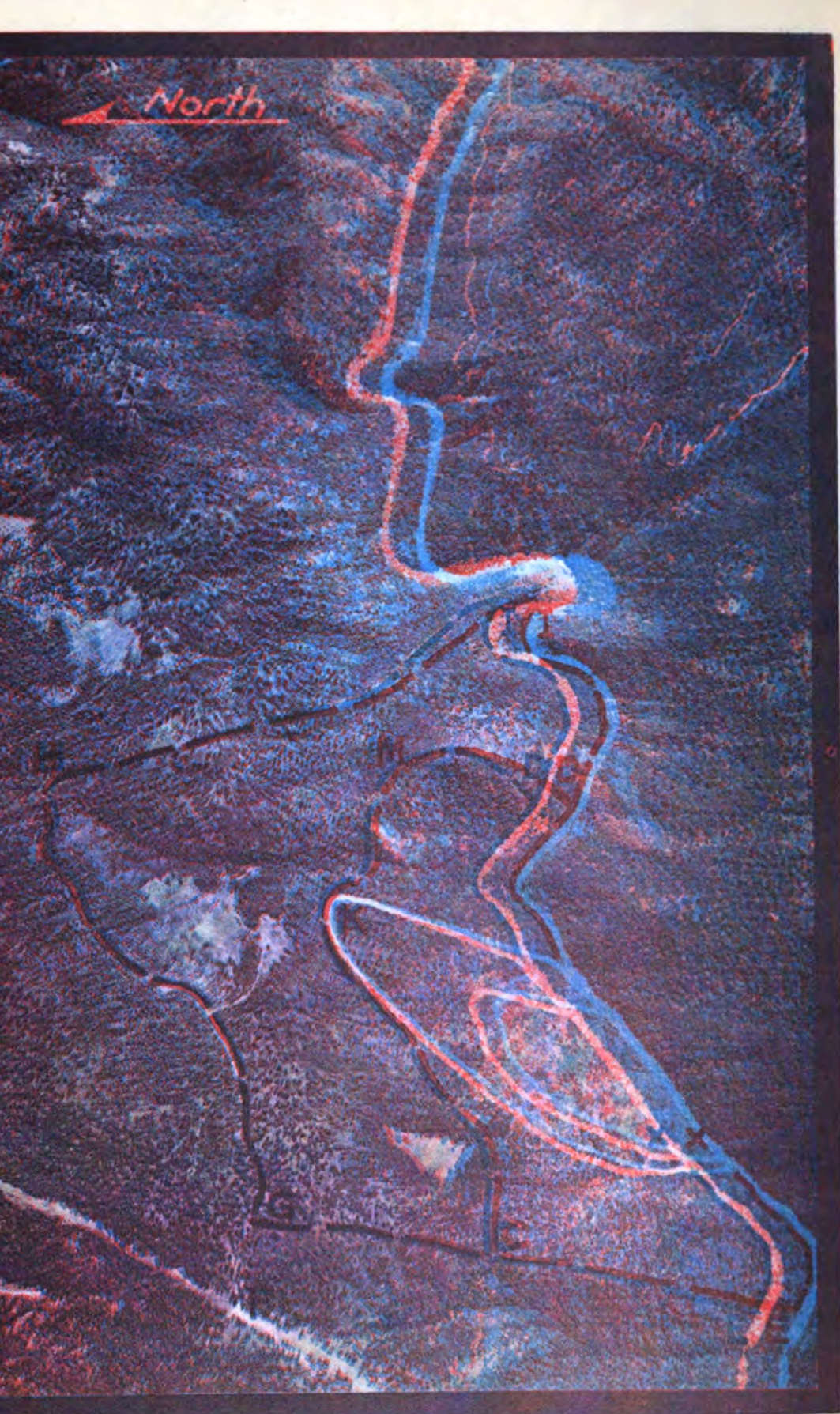
1. Under conditions at 5:00 P.M.

Fire boss calculates that fire will reach topographic break above the river in the vicinity of K around 6:00 P.M. This will eliminate the possibility of using this break as a control line location since man-



Fig. 46

Scale 2" = 1 mi



power cannot be placed on this line sufficiently in advance to do the necessary work to hold the fire.

The next practicable line appears to be along the cleared power line H to I and along the trail H to G with the line tied back to the river from G to E. Fire according to computation should not reach H before 8:30 P.M. because the rate of forward spread on the reduced slope will drop from 28 to 14 ch. per hour.

The fire boss plans to send 50 men who are due to arrive at F at 6:00 P.M. to point H which they should reach before 7:00 P.M. The crew would be split and proceed with the necessary cleaning out of the power line and trail and backfiring toward G and I. This should assure the checking of the head of the fire.

As additional crews arrived they would be sent in to supplement these men now working to patrol and hold the river and to follow up the trailbuilder which would have been put to work on line on ridge from G to E. This would be backfired to the river on completion and after line H to G had been cleaned up.

2. Under conditions at 6:00 P.M.

When the down canyon change in wind took place, the velocity unexpectedly continued at 15 mi. per hour. This naturally had a very strong effect in holding the head of the fire at K from spreading up the slope.

The fire boss ascertained just what was happening from an adjacent lookout who could look right down on the area and found that the fire had not gone very far over the topographic break and was now spreading down canyon toward C-E rather than up the slope. See larger area enclosed by white line for location of fire at 6:00 P.M.

Plan to use line G-H-I was abandoned completely and the 50 men due at F were diverted from that line.

Men and trailbuilder were assigned to put in line C-E and to hold the river.

As additional men came in they were assigned to the construction of lines from C to K to M to D which were then fired out and became the final control lines.

Supplemental

Fire boss really had two plans of control in his mind and when conditions changed he shifted his plan from one to the other.

CHANGES IN WEATHER

WEATHER CHANGES FOR BETTER AFTER ATTACK INITIATED NECESSITATES CHANGE IN SUPPRESSION PLANS

Problem 3

USE FIGURE 47

Conditions

Region: West side, Zone 1.

Time of year: Mid-June.

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: 270 ac.

Perimeter when planning begins: 233 ch. of which 83 ch. were not controlled.

History: Incendiary fire started at points (x-x) at 2:00 P.M.; W. to SW. wind, 10 mi. per hour; relative humidity, 20%; fuel moisture, 4%. By 5:00 P.M. the heel and flanks were controlled by means of backfiring along lines, roads F-H and H-E-C, and along bottom of draw F-M.

Weather at 5:00 P.M.: Sharp, unpredicted change in weather due to local disturbance that was not predicted. Relative humidity, 90%, due to some rain; fuel moisture rapidly increasing; wind down to 3 mi. per hour.

Topography: Slopes gentle over area except along both sides of draw F-M which are steep.

Types: Medium to heavy manzanita with few stringers of scattered trees in draws.

Manpower available: As needed.

Equipment available: Backfiring and hand tools, one tank truck.

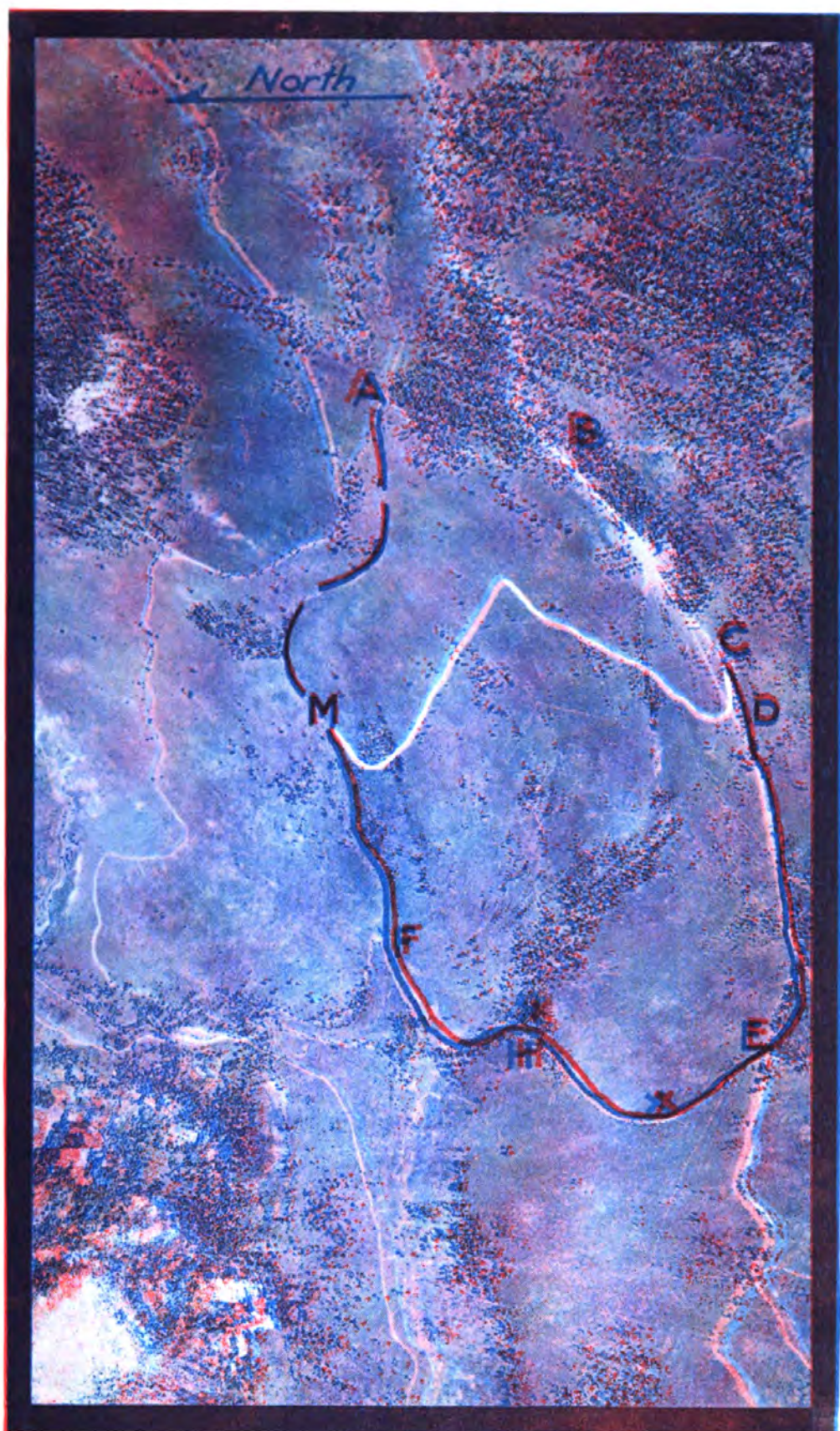
Roads: A-B-E-F, also others, though having no effect on this problem.

Solution Required

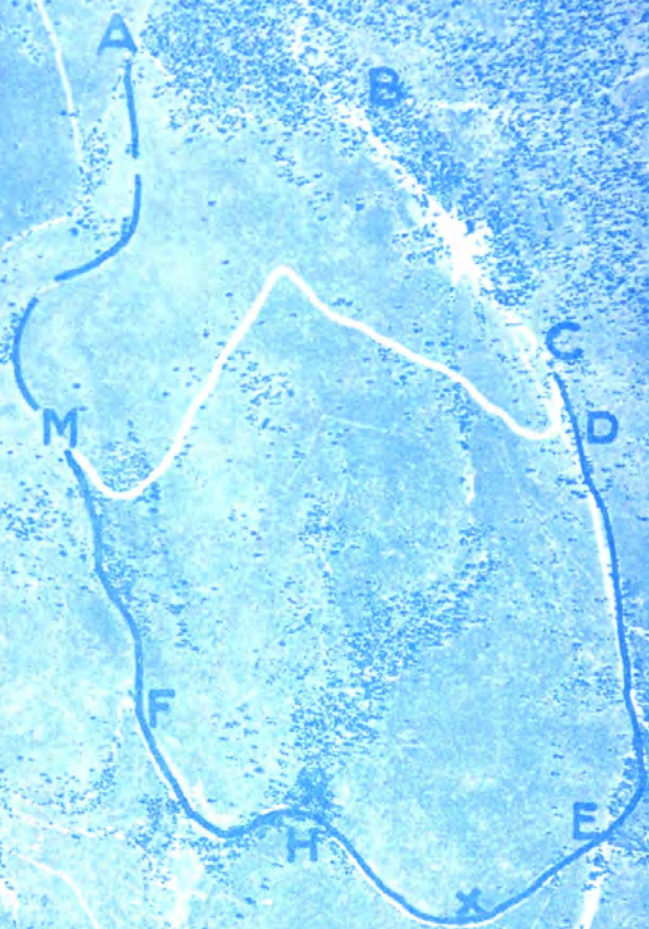
With an unpredicted sharp increase in relative humidity from 20% to 90% what change in plan is necessary to meet this new situation?

Acceptable Solution

1. The original plan was to backfire roads F-E-B-A and draw F-A; backfiring along the heel and flanks thence when expected change in wind occurred to backfire the head.
2. When this radical change in weather occurred the fire boss decided to change his plan of attack from backfiring to direct attack and cold trailing. To do this he must cold trail the sections of backfired line as well as the head of the fire. This decision resulted in the loss of 100 man hours of labor that were used to construct line M-A but was considered to be an acceptable loss, since to continue to backfire



North



after conditions made this impossible would have resulted in increased labor costs the next day to hold the fire along a poorly burned-out line.

Supplemental

Weather conditions changing the burning conditions from a very low rate of spread to a high rate of spread would reverse the above described situation and instead of trying to apply direct attack tactics to a fire that was minute by minute becoming more difficult the decision would be to drop back to an indirect attack plan to effect control. Such decisions must be made with dispatch, since to wait only increases the difficulties that will be encountered. Always have a second plan of action to care for such situations.

POINTS TO CONSIDER IN EFFECT OF WEATHER CHANGES ON CONTROL PLANS

1. Fire boss should be prompt in recognizing when major changes in current weather have taken place that will warrant or require a change in the plan of control of a fire.
2. Fire boss should be quick to take advantage of improving weather condition that will permit a change in plan resulting in quicker control at a reduced acreage.
3. When conditions develop that are worse than anticipated, fire boss must shift promptly to alternate plan he had in his mind in case the first one did not work out.

BACKFIRING

Foreword

Backfiring as a widely applicable technique in the control of fires is generally recognized. The key techniques in its successful use, such as carrying backfiring operations downhill and having backfires burn uphill, utilizing the draft of the main fire to control the backfire, timing backfiring operations to take advantage of current and impending weather conditions, using special equipment in the operation—all these are fairly well known.

In principle it is widely understood that often backfiring has everything to gain and little or nothing to lose, and that even though lost, it is better to have taken the chance.

But review of many fires reveals numerous cases in which backfiring opportunities were not taken. Quite apparently the reason is often, not lack of recognition of opportunity or knowledge of technique, but rather a feeling that backfiring is unsafe and a gamble, while direct attack is safe and sane, or that loss of a backfire carries some implication of avoidable error. In short, the systematic practice of backfiring when indicated seems less a matter of technique than of will.

A number of common situations in which backfiring is indicated are covered by problems under various headings, and particularly under "Emergency Action." Other recurring situations are covered by problems here.

BACKFIRING

BACKFIRING OR DIRECT ATTACK

Problem 1

USE FIGURE 51

Conditions

Region: Southern California, Zone 1.

Time of year: September

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: Approximately 519 ac. which are partially controlled.

Perimeter uncontrolled: 120 ch.

History to date: Fire started 11:00 A.M. at foot of slope A-C, ran up slope and spotted over ridge B-D and established itself on opposite slope; the available forces have succeeded in stopping the fire on all sides except on north slope of 65%. Direct attack has been attempted on this sector which drops down into a deep, wide gulch A-C.

Current weather: Wind, 6 mi. per hour; relative humidity, 15%; fuel moisture, 3%.

Predicted weather: Weather becoming more favorable during night; slightly worse conditions predicted for the ensuing day with lower fuel moisture and higher wind.

Elevation: 2,000' point (x), ridge B-D 3,600', canyon M-N 2,400'.

Topography: Rugged with deep canyons. Slopes 65%.

Types: Chaparral from 8 to 10 feet high, unburned for 50 years. Ground very rocky and almost impossible to build clean line.

Barriers: Firebreaks—B-D and P-R.

Manpower: Sufficient men are on the fire to handle any reasonable plan of attack and to execute any strategy that may be decided upon.

Values: Watershed of extremely high value.

Solution Required

What should the fire boss do at this stage of the battle and why?

Acceptable Solution

Three main courses of action are possible:

- a. Continue hitherto unsuccessful efforts at direct attack.
- b. Clean out the main gulch M-N and man it with sufficient men to hold the fire as it backs down the slope into it.
- c. Backfire the gulch M-N just as early in the night as possible after cleaning it out, and with suitable backfiring equipment.

The real arguments in favor of the latter course are:

1. Direct attack south of ridge B-D probably hopeless because of rolling material and difficulty of getting clean line.
2. Uncertainty as to how fast the main fire would burn down into gulch M-N.
3. Possibility this would be slow, and during the runs might spot across into the unburned territory across the gulch next day when conditions were bad.
4. The control force would be handling the fire at the time it could be taken care of and not waiting for nature to take its course.
5. The fire should be in the best possible shape when the predicted change for the worse in weather takes place.
6. If the plan of action succeeds the area burned is no larger than would have resulted in any event, and the threat of increased size is reduced.
7. If plan fails firebreak along ridge P-R can be manned as soon as failure of first plan is known.

The only real disadvantages are the chance that the uphill burning of the slope might create enough momentum to spot up the opposite slope while the uphill burn will be somewhat more severe than would have resulted from the downhill one.

After weighing everything, the fire boss decided to backfire the gulch and this was done promptly and successfully.

BACKFIRING

TECHNIQUE OF BACKFIRING UNDER UNFAVORABLE CONDITIONS

Problem 2

USE FIGURE 48

Conditions

Region: West side, Zone 1.

Time of year: Mid-July.

Time of day when planning begins: 10:00 P.M.

Size of fire when planning begins: 287 ac.

Perimeter of fire when planning begins: 240 ch. of which 105 ch. free burning edge of fire.

History to date: Fire started point (x) at 4:00 P.M. With a relative humidity of 14%, a fuel moisture of 3%, and an upslope wind of 15 mi. per hour the fire rapidly advanced up the slope and by 8:00 P.M. at which time the weather began to moderate, it had progressed forward 73 ch., crossing road B-C. By 10:00 P.M. the fire was controlled along flanks B-A and A-C. The head of the fire B-D-C from 8:00 P.M. to 10:00 P.M. had advanced 20 ch. Figure shows location of fire at 10:00 P.M.

Weather, current: Wind down slope, 1 mi. per hour; relative humidity, 29%; fuel moisture, 4.5%.

Predicted: Slowly rising relative humidity during night, no other change.

Elevation: Canyon bottom, 2,800'; road E-F, 4,000'.

Topography: Numerous narrow draws draining northwest into canyon. Along road E-F and to southeast terrain rolling with numerous shallow draws; slope 5% to 10%. Slopes from D to canyon bottom average 16% with side slopes into draws averaging 25%. Last 10 ch. into canyon very steep.

Manpower available: All men on lines A-B and A-C needed for holding except 60 men who may be released to assist in controlling head of fire. No additional men.

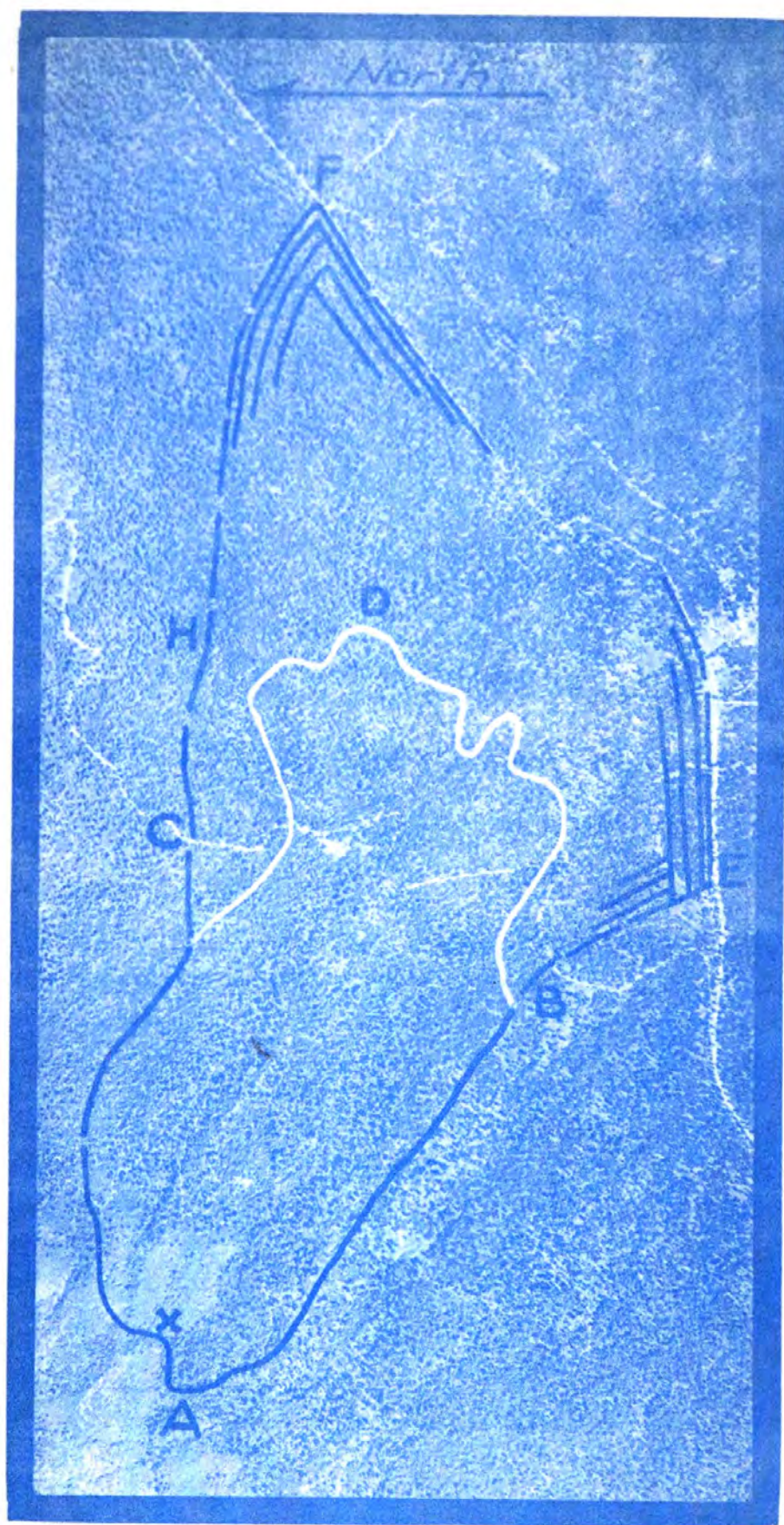
Equipment available: Backfiring and hand tools only.

Roads and trails: Roads E-F and B-C, trail F-H.

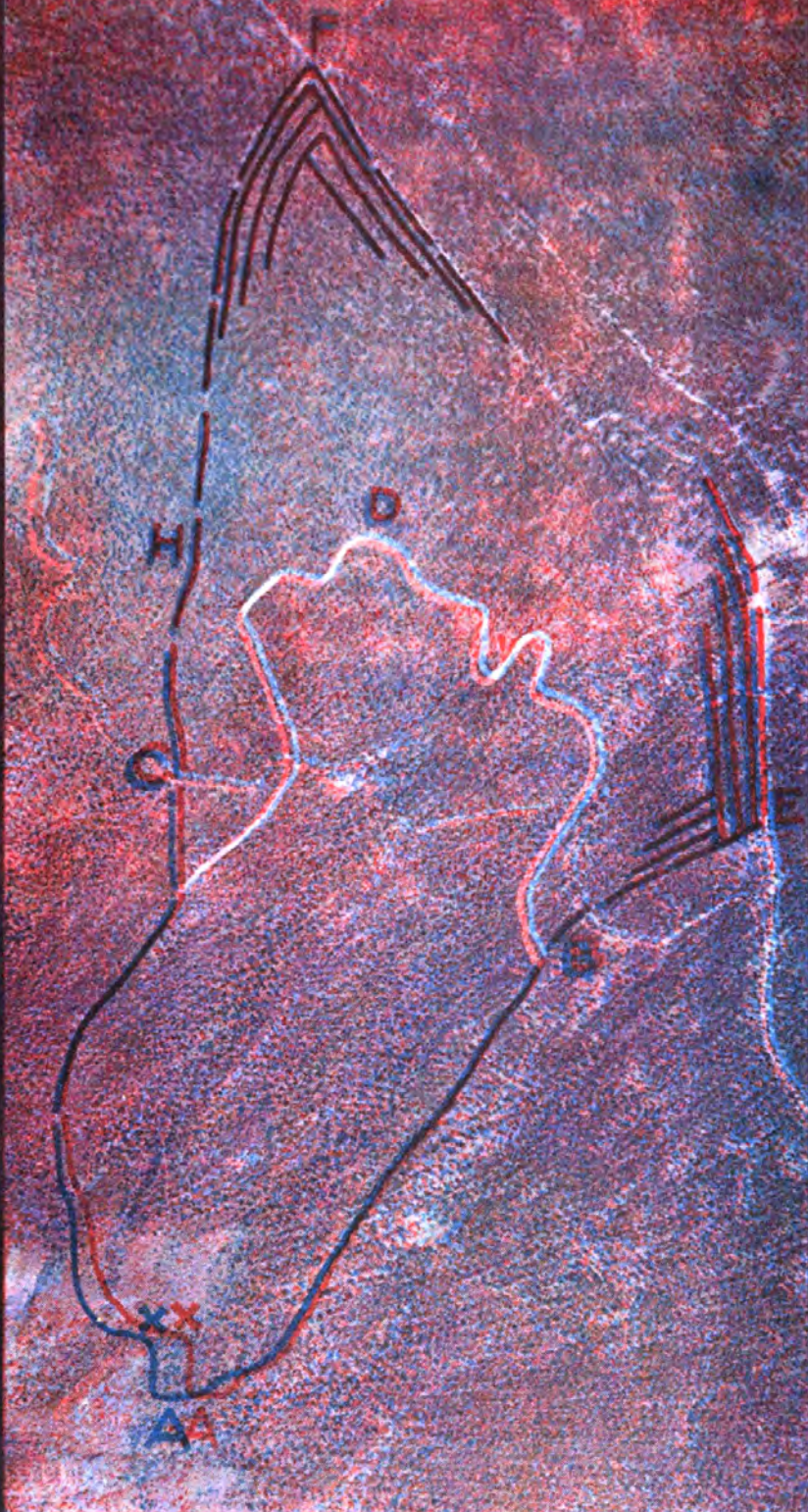
Rate of spread types: Heavy brush in canyon bottom and for short distance up slopes. Remainder of area closed mature stand of ponderosa pine timber with pine needle ground cover except immediate area in which major head of fire is burning and for 20 ch. in advance of D, which has in addition numerous snags and down logs.

Solution Required

What backfiring technique should be used to assure control under adverse humidity conditions?



No. 15



Acceptable Solution

1. Due to snags and down logs in the vicinity of head of fire direct attack on head is not desirable since with normal upslope wind the next day this line would be difficult to hold.
2. Line B-E-F-H-C is selected for the control line.
3. The relative humidity was 14% at 4:00 P.M. and 29% at 10:00 P.M. Continued slowly rising humidity was predicted. On the basis of the above rise this would be at the rate of approximately $2\frac{1}{2}\%$ per hour. This indicates that after 1:00 A.M. a backfire would not burn down a reverse slope, since by this time the relative humidity would be approximately 37% and the fuel moisture would increase correspondingly. The fire boss decides that he must complete the job by 1:00 A.M., realizing that he has a tough backfiring job from the start.
4. 30 men from line B-A are brought to point E by truck. 3 men from line A-C are instructed to construct line to C-H. 25 men from line A-C are brought to point F by truck. Instructions are given and all set to go by 10:30 P.M.
5. Due to the high relative humidity conditions prevailing and the increase expected the fire boss lays out the following backfiring plan to assure that the backfire would be burned back into the main fire by 1:00 A.M.:
 - a. 3 men to construct line from E to B.
 - b. 3 men to construct line from C to H point on trail.
 - c. Simultaneous with this work the backfire will be carried forward as follows:
 1. Starting from E and F backfires will be set along lines E-B, E towards F, F towards E and E towards C.
 2. As soon as the backfire is started along these lines auxiliary backfires will be set inside these lines so that the first auxiliary backfire is 50' inside the primary line, the second 100 to 150' inside the first auxiliary backfire line and the third 200' below the latter. If the actual spread of the primary and auxiliary backfires does not spread towards the main fire rapid enough to meet the deadline period of 1:00 A.M. other auxiliary backfires will be started. See figure 48 for diagrammatic scheme of carrying these backfires forward.

BACKFIRING

TIMING OF BACKFIRE DEPENDENT ON WEATHER CONDITIONS

Problem 3

USE FIGURE 49

Conditions

Region: West side, Zone 1.

Time of year: Mid-August.

Time of day when planning begins: 4:30 P.M.

Size of fire when planning begins: 92 ac.

Perimeter of fire when planning begins: 165 ch.

History of fire: Started at 11:30 A.M. Small crew initial attack unsuccessful so this crew worked along west flank from river at C to point E in gulch. Ranger arrives at point A with 50 men at 4:15 P.M. Other men arrived at C at approximately same hour.

Current weather: SW. wind, 6 mi. per hour; relative humidity, 20%; fuel moisture, 4.5%.

Predicted weather: Increasing relative humidity from 7:00 P.M. on, reaching 40% by 9:00 P.M.; fuel moisture, 8.0%; wind, down canyon 1-2 mi. per hour. For following day relative humidity will drop to 20%, fuel moisture to 4.5% and wind will switch to SW. and increase to 20 mi. per hour.

Elevation: 4,200' at river to 4,600' on ridge.

Topography: General gentle (10-15%) slope from highway and river to main ridge top. Gulches with moderate to steep sides.

Rate of spread types: Scattered ponderosa pine with an understory of mixed brush and reproduction over whole area. Under stated weather conditions has spread at rate of 33 ch. perimeter increase per hour.

Barriers: Power line A-B; highway and river to east of fire, C-D; telephone line clearing SE. from A to D.

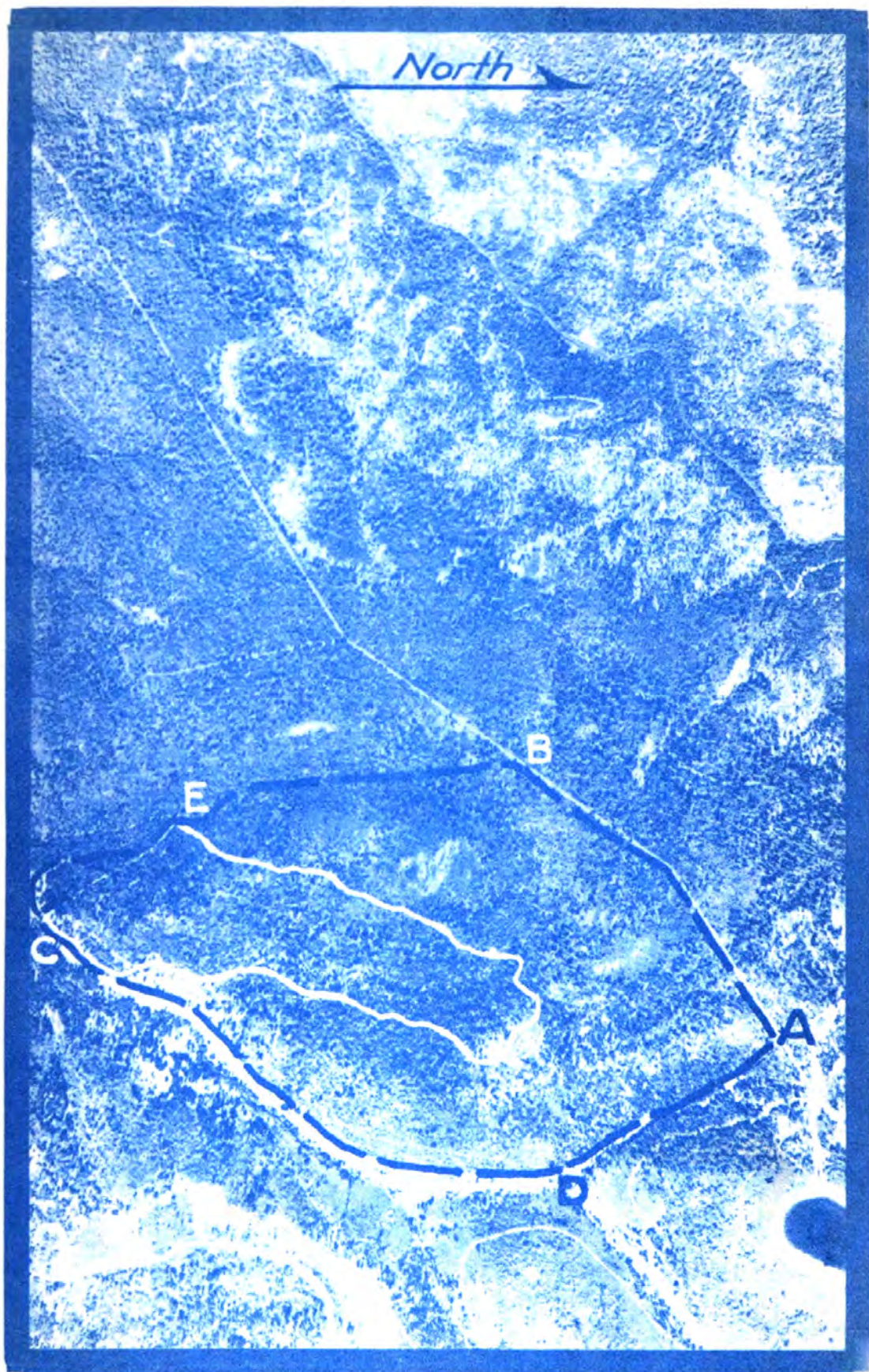
Manpower available: 50 men at A at 4:15 P.M.

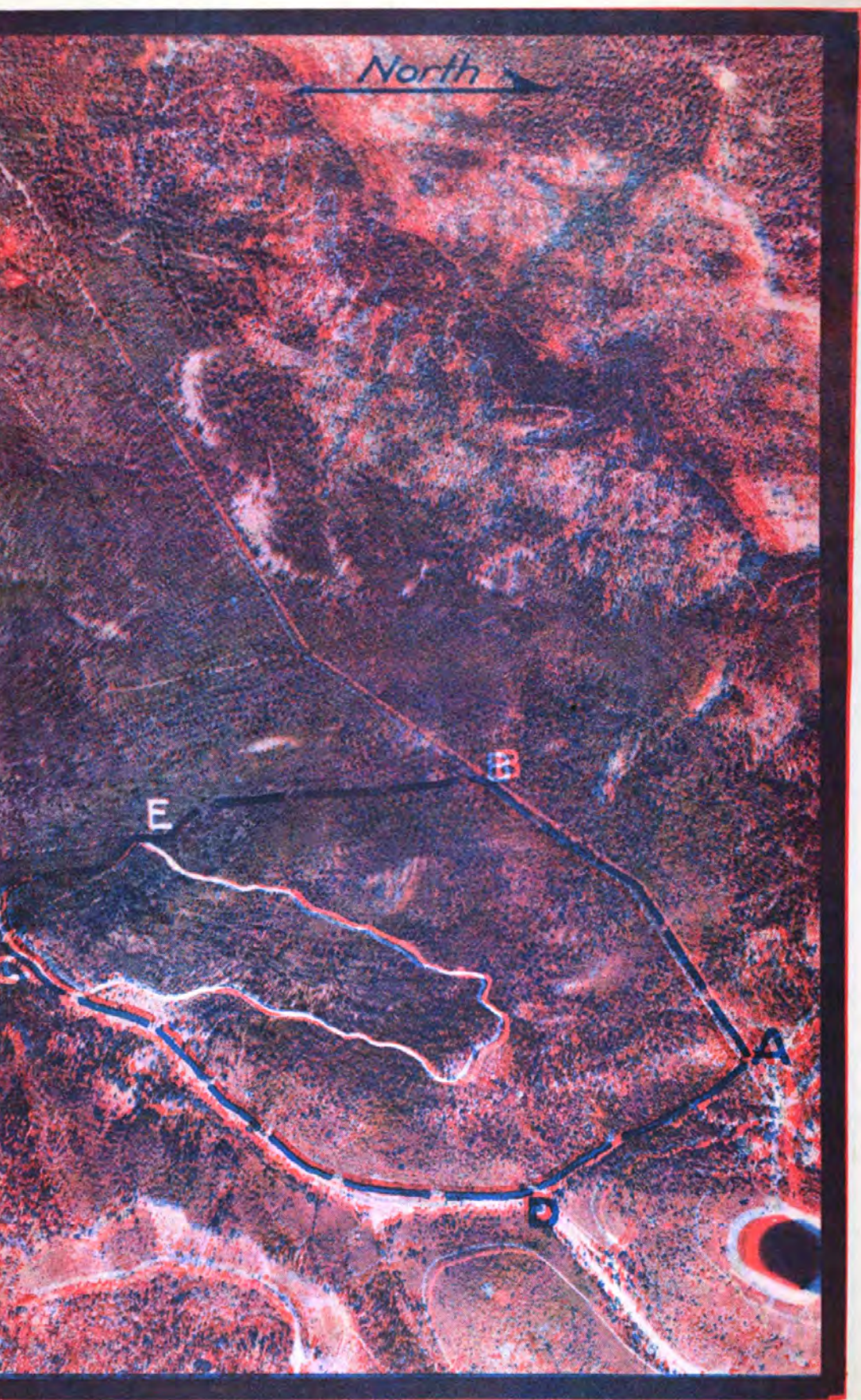
Equipment available: Adequate hand tools, backfiring torches and special equipment, back pack pumps.

Roads: Within 100 yards of point north of A and highway along river C-D.

Solution Required

1. At what time would backfiring be started and why?





Acceptable Solution

The fire boss placed his forces and started the backfire from A at about 4:30 P.M. From 4:30 P.M. to 7:00 P.M. the fuel moisture conditions will aid the backfire and secure a complete burn well back from the lines A-B and A-D sufficient to hold strong runs from the main fire the following day. Other men in sufficient numbers were placed on sector C-E-B to complete and fire out line C-E-B from top down after line A-B had been completed. Under conditions expected, if start of the backfire were delayed until 6:30 or 7:00 P.M. or later, crews would not be able to finish the backfiring of line A-B before the burning conditions become unfavorable. In addition, after the first hour the backfire would be hard to start, consume an increasing amount of manpower and time, and be incomplete and spotted with singed or unburned canopy.

Under fuel moisture and humidity conditions predicted it would not be possible to obtain a clean backfire after about 8:00 P.M. that would hold the fire the next day when burning conditions again become dangerous.

Rate of spread would decrease materially at 7:00 P.M. to 8 to 10 ch. per hour, which means that fire would not reach the Ponderosa Way during the night. However, the fire would burn with sufficient force during the night that cold trailing could not be successfully done. The fire would come to life in the early morning and the perimeter would increase with the worse burning conditions at a rate of 80 to 90 ch. per hour, hitting the Ponderosa Way hard at 9:00 A.M., which would mean the loss of the fire on the ridge A-B.

BACKFIRING

APPLYING BACKFIRING TECHNIQUE THAT WILL STOP THE HEAD OF A FAST-SPREADING FIRE

Problem 4

USE FIGURE 50

Conditions

Region: West side, Zone 1.

Time of year: Mid-August

Time of day when planning begins: 3:15 P.M.

Size of fire when planning begins: 197 ac.

Perimeter of fire when planning begins: 210 ch.

History: Fire started in sharply defined canyon at point (x) at 11:00 A.M. and, according to the lookout who had direct visibility into the canyon and surrounding area, crossed the break in topography 15 ch. north of the river in 15 minutes after start. Forward progress was 80 ch. by 3:15 P.M.

Weather: S. wind (up slope), 12 mi. per hour in open; relative humidity, 15%; fuel moisture, 3.5%. No change predicted next 6 hours except slightly improved relative humidity and fuel moisture conditions.

Elevation: Starting point (x) 2,500'. Break in topography 15 ch. north 3,300'. Head of fire 4,000'.

Topography: Very steep slopes into canyons A-B and B-C, Moderate slopes into canyon D-A. Gentle slopes (16%) rising to the north for 30 ch. beyond head of fire. Thirty chains north of head of fire is a shallow saddle (the head of a drainage at the beginning of the high plateau draining to the north). Remainder of area, high plateau draining west and southwest.

Rate of spread types: Heavy mixed brush along steep slopes of canyon in which fire started; remainder of area mature closed stand of ponderosa and sugar pine timber with ground cover of pine needles. Very little down stuff in timber stand.

Manpower available: As needed at head of fire.

Equipment available: Hand tools only.

Roads: Road to point E only.

Values: High timber values especially to north.

Solution Required

What technique in backfiring should be applied to stop the head of this fire in the shortest time?

Acceptable Solution

1. Satisfactory progress is being made along heel and flanks of fire, thus they can be eliminated from consideration, since once the head is stopped the men on these lines can build and hold line faster than fire is creating new perimeter.





Fig. 50

2. The fire boss calculates that the fire is spreading along its axis 15 ch. per hour; that this rate of advance may be expected to continue, since the weather will improve but slightly.
3. Sizing the fire up he sees that the head is very hot. This eliminates the possibility of direct attack. Also that it will be very difficult to stop the head of the fire once it reaches the shallow saddle 30 ch. to the north due to the funneling effect of the wind as it pours through this saddle.
4. He decides backfiring is the solution but will be difficult unless handled successfully because of:
 - a. Hotness of head.
 - b. Wind direction and velocity.
 - c. The rapid advance of fire.
 - d. Low fuel moisture of forest floor fuels.
 - e. Possibility of spotting.
5. To minimize these difficulties he calculates what work he must do to make the backfire successful, determines the time it will take to do this work and locate the control work sufficiently far in advance of the head to give him time to complete the job. This distance figures out to be 20 ch. He then begins line construction at point G (a wing line far enough to the west to prevent outflanking) and proceeds northward to point H; thence east to point I; thence south to point K (the terminus of the east wing line). Simultaneous with the construction of this line he carries multiple backfires forward as the line progresses from the west toward the east. The first backfire is set along the constructed line starting a short distance above the lower extremity of the wing line to eliminate outflanking; the auxiliary backfiring lines progress in an easterly direction, keeping slightly in the rear of the primary backfire. See figure 51 for layout of backfire.
 - (1) = Primary backfire and constructed line.
 - (2) = 1st auxiliary backfire. No constructed line.
 - (3) = 2nd auxiliary backfire. No constructed line.
 - (4) = 3d auxiliary backfire. No constructed line.

Men for holding are left on the line.

This method will assure a wide, well-fired burned area for the oncoming fire to hit, thus reducing the possibility of it either crowning or spotting over the line. The auxiliary backfires tend to pull in the primary backfire, thus overcoming the effect of the wind, which is not great in the closed stand of timber.

BACKFIRING

TIMING OF OPERATIONS DEPENDING ON TOPOGRAPHY

Problem 5

USE FIGURE 51

Conditions

Region: Southern California, Zone 1.

Time of year: Mid-September.

Time of day when planning begins: 5:00 P.M.

Size of fire when planning begins: 519 ac.

Perimeter of fire when planning begins: 259 ch.

History to date: Started point (x) 11:00 A.M. Crossed ridge B-D in three sections about 4:00 P.M. Attack on lines A-B and C-D completed and holding to ridge B-D.

Current weather: Slightly above normal for the period.

Predicted weather: Normal night reduction in spread, back to high Class 4 next P.M.

Elevation: 2,000' at point (x); 3,600' ridge B-D; 2,200' to 2,400' in canyon M-N.

Topography: Very steep slopes.

Rate of spread types: Mixed brush.

Resistance to line construction type: Mixed brush.

Barriers: Firebreak ridge B-D already lost; A-C holds except for patrol; canyon M-N needs little work to clear out.

Manpower available: Any number needed in 45 minutes at end of road near point B. Any number needed in 1½ hours, point N. Any number needed can walk from B to point D in 1½ hours.

Equipment available: Hand tools and backfiring equipment.

Values: Exceedingly high for watershed.

Solution Required

How to obtain complete control of fire?

Acceptable Solution

1. Direct attack on excessively steep slopes leading to canyon M-N bound to fail because of roll.
2. Back up to canyon M-N, build side lines from near B to near M, and from near D to near N, and backfire out whole slope necessary.
3. Timing and order of operations used as follows:

Start work:

- a. Start crew cutting line down point B-M.
- b. Clean out canyon from N-M preparatory to backfiring.
- c. Start crew cutting line down point D-N.
- d. Soon as safe place small select crews to check slopovers and try to prevent rapid spread.

Timing of backfires:

- a. Start from B; carry backfire down line to M; thence down canyon toward N. At about time backfire reaches point M, start backfiring from D toward N. This should be completed by time crew working from M reaches about point E. Then finish from N to E.





BACKFIRING

USE OF TEMPORARY FIRE LINES TO DELAY PROGRESS OF FIRE

Problem 6

USE FIGURE 52

Conditions

Region: East side, Zone 2.

Time of year: Mid-July.

Time of day when planning begins: 2:00 P.M.

Size of fire when planning begins: 22 ac.

Perimeter of fire when planning begins: 90 ch.

History to date: Fire started at 12:30 P.M. at point (x) on north bank of river. Its initial run fingered badly and at 2:00 P.M., while the body of the fire had moved north above 20 ch., fingers of fire had advanced 30 ch. at points F and G. At 2:00 P.M. finger at F was 15 ch. from ridge C-D; G and H were 5 and 7 ch., respectively, from ridge B-C.

At 2:00 P.M. the fire boss arrives at point C on ridge and looks over situation. He realizes line C-D must be constructed and held as there is no other available location for a line to the northeast without sacrificing a large area. He notes line C-B-A may be constructed and held if it can be completed and backfired before it is crossed by the fire.

Current weather: SE. wind, 10 mi. per hour; relative humidity, 15%; fuel moisture, 4%. No change predicted.

Elevation: 5,500' at point (x) on river, 6,100' at point C on ridge.

Topography: Moderate 25% slope from river to point C, with the steeper slopes being nearer the river.

Rate of fire spread: With 10 mi. wind and average 25% slope, average linear spread of free fire 10 ch. per hour.

Resistance to line construction: RD-7 trailbuilder with crew can build 25 ch. of line per hour on ridge B-C-D. Hand line can be built at rate of 10 ch. per hour with 8-man crew. (Scattered timber with reproduction and brush on slopes near river with more brush near, and on, ridge B-C-D.)

Barriers: River—SE. of fire. Road K-L forms partial barrier. Cleared telephone line L-B-A forms partial barrier.

Water available: River.

Manpower available: Fire boss brought 25-man crew with him to point C at 2:00 P.M.

Equipment: 3 RD-7 trailbuilders with crews at point C at 2:00 P.M.
25-man crew equipped with hand tools.

Roads: On line K-L.

Values: Timber stands becoming more valuable to north.

Solution Required

Plan of attack, location of temporary and permanent control lines, and distribution of men and equipment.

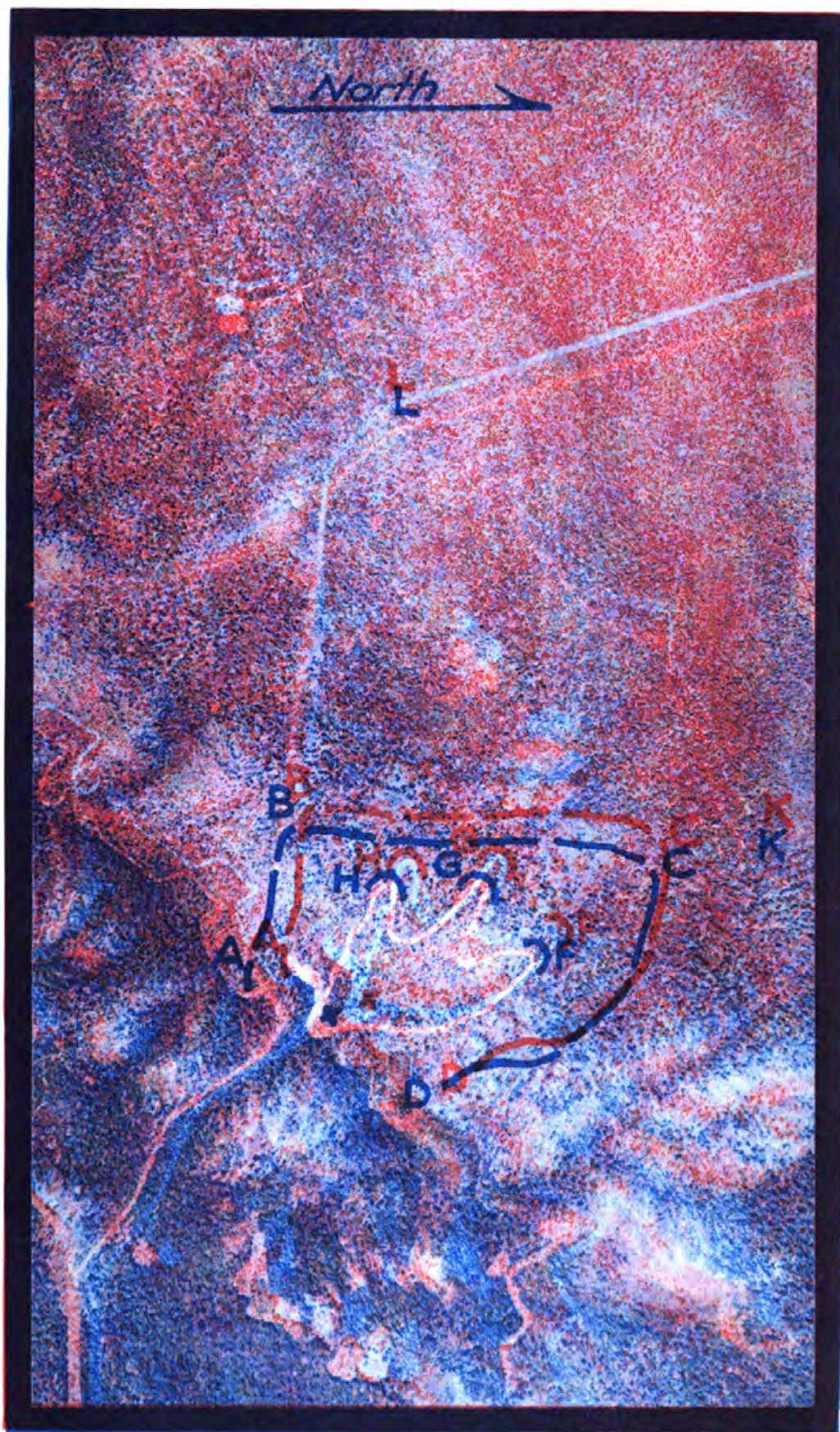
Acceptable Solution

Fire boss dispatches 2 RD-7 trailbuilders to construct line C-D (55 ch.). This is the most vital sector of fire and minimum chance must be taken on its successful construction. It will take one hour for two tractors to build this line (2:15-3:15 P.M.). The fire boss estimates that fire from the finger at point F, which is only 12 ch. from the line C-D, may reach line C-D by 3:15 P.M., but to make sure the fire is delayed, he dispatches a crew of 8 men to build and backfire from a temporary line around the end of fire at point F. This line delays fire advance one hour, and fire does not reach line C-D until 4:15 P.M. Crew falls back to line C-D after constructing temporary line at F. It backfires this line, following completion of tractor line at 3:15 P.M. and holds line with time to spare.

At 2:15 P.M. fire boss sends one RD-7 trailbuilder to construct fire line on ridge C-B, thence down cleared telephone line to point A. It will take two hours to complete this line C-B (50 ch.). Line B-A can be constructed in a few minutes. The fire boss estimates fire from points G and H, if checked, will reach and cross line C-B in just over thirty minutes unless the fingers of fire G and H are checked. He sends two crews of eight men each to construct and backfire from temporary fire lines at G and H, where fire enters heavier brush.

The two 8-man crews build temporary lines encircling the ends of fire fingers at G and H, and by backfiring delay the fire advance about one and one-half hours. The fire, therefore, does not reach line C-B until after 5:00 P.M. The crews fall back from points G and H to line C-B after this line is constructed by the tractor and start backfiring just before 5:00 P.M. The tractor constructs line B-A from 5:15 P.M.-5:30 P.M., which is then backfired and line C-B-A is held.

Fire is controlled on line A-D-C-B-A with final perimeter of 125 ch. (exclusive of river) and total area of 70 ch. Control on this line was only possible due to construction and backfiring of the temporary fire lines which delayed the advance of fingered portions of the fire from one-half to one and one-half hours.



North →

L

B

H

G

C

K

A

F

D



BACKFIRING

USE OF TEMPORARY FIRE LINES TO DELAY PROGRESS OF FIRE

Problem 7

USE FIGURE 53

Conditions

Region: West side, Zone 1.

Time of year: Early August.

Time of day when planning begins: 11:30 A.M.

Size of fire when planning begins: 10 ac. (20 ch. long).

Perimeter of fire when planning begins: 45 ch.

History of fire: Fire started at 10:10 A.M. at point (x).

Current weather: SE. wind, 10 mi. per hour; relative humidity, 15%; fuel moisture, 3.5%. No change in weather predicted.

Elevation: Point (x), 7,000'; ridge G-I, 7,400'.

Topography: Relatively level from point (x) to line C-D; 30% slope from C-D to ridge line G-I.

Rate of spread type: Timber with some reproduction and brush. In this type with 10-mile wind and no slope, linear advance of fire will average 15 ch. per hour. With 30% slope linear advance increases to 30 ch. per hour.

Resistance to line construction: Hand line constructed at rate of 10 ch. per hour by 8-man crew.

Barrier: Road on ridge along line G-H-I, partial barrier if manned.

Water available: Spring and well at point G on road.

Manpower available: 16 men arrive with fire boss at 11:30 A.M., point H on road.

Equipment available: 16-man crew equipped with hand tools. Tanker and crew not due to arrive at point H at 4:30 P.M. because it is on another smaller fire.

Road: Ridge road on line G-H-I.

Values: Good stand of merchantable ponderosa pine timber.

Solution Required

Plan of action to prevent fire reaching line G-H-I or to delay it reaching this line before 4:30 P.M.

Acceptable Solution

1. On arrival at point H on road fire boss with 16-man crew see fire and plan control. Fire boss estimates fire is 50 ch. from ridge G-H-I. He estimates it will reach base of slope D-C in 2 hours (1:30 P.M.) and ridge G-H-I in 40 minutes additional, or by 2:10 P.M. He feels that he and crew cannot hold the unchecked fire on ridge road G-H-I without tanker, which will not arrive until 4:30 P.M. This because of width of head and speed of forward progress. He must stall fire, attempt to control it, or reduce the width of the head when it hits ridge G-H-I.

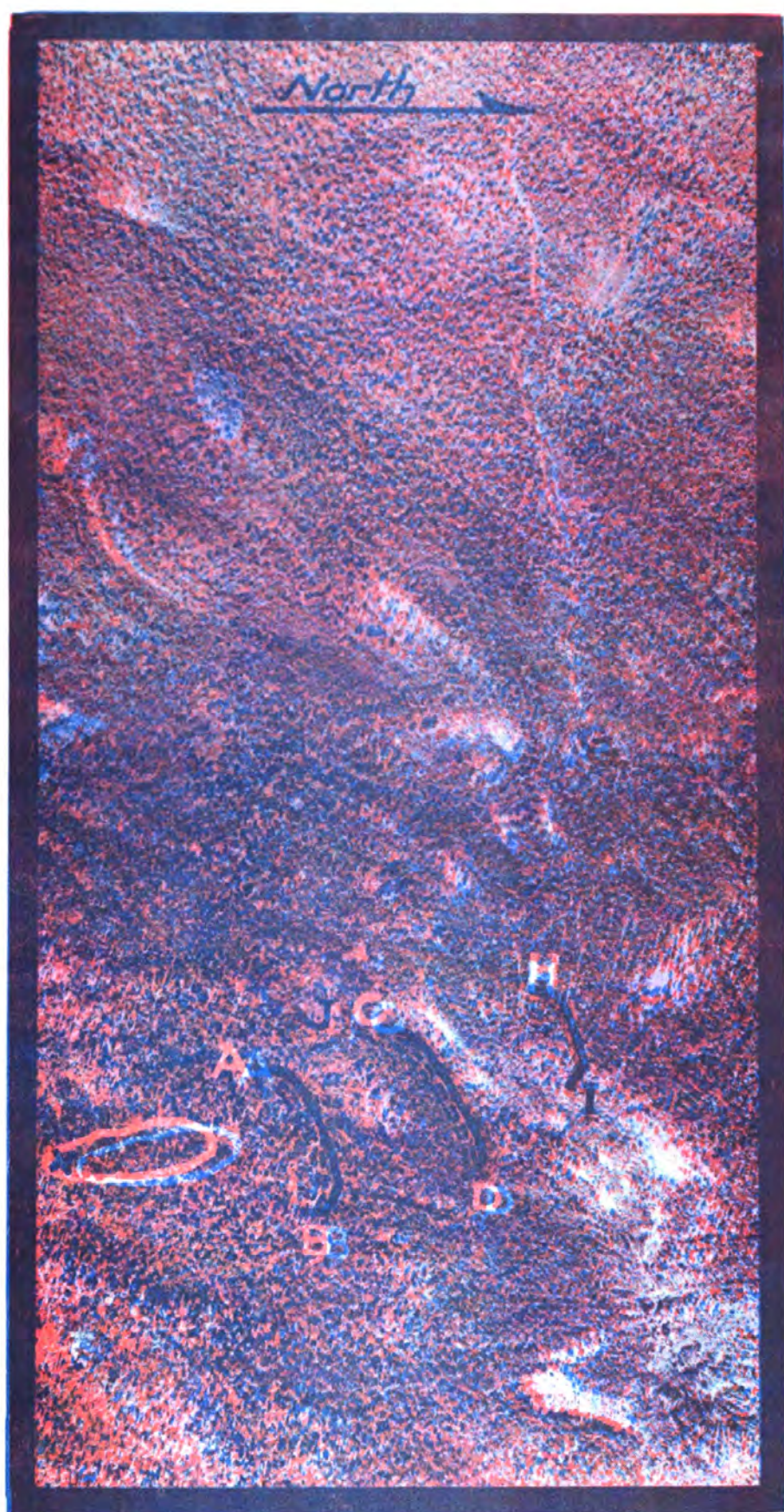
2. *Stalling the advance of the fire:*

A minor ridge extends southward from point H on ridge. Fire boss takes his 16-man crew down this ridge to point A on relatively level ground, reaching point A at 11:45 A.M. The crew constructs and backfires 20 ch. of fire line (from point A to point B) which faces the approaching head of fire between 11:45 A.M. and 12:45 P.M. Free fire reaches line A-B at approximately 1:00 P.M. He attempts to hold this line but at 2:00 P.M. fire spots over line in several places, resulting in loss of line.

3. Fire boss brings crew 18 ch. north (base of slope D-C) and constructs and backfires another fire line along D-C, completing this job by 3:15 P.M. Fire hits this line by 3:15 P.M. and is held for one hour, spotting over line in one place at 4:15 P.M. Spot too hot to handle on steep slope. As soon as the fire boss sees second line (D-C) has been crossed he retreats to ridge road line G-H-I via ridge J-H, where additional clearing is done preparatory to arrival of tanker. Fire reaches ridge G-H-I at approximately 5:00 P.M. The two temporary fire lines A-B and D-C result in stalling the fire, delaying its forward progress so it does not reach road G-H-I until 5:00 P.M. instead of 2:10 P.M. as previously calculated. Also the width of the front is considerably reduced. The tanker arrived at point H on line G-H-I at 4:30 P.M. and fire boss with crew, even though wearied, had no difficulty in controlling the head of the fire on the 10-ch. front along line H-I at 5:00 P.M. The sides of the fire were later controlled without difficulty by direct flank attack. (There was a hope, though a slim one, that the fire might be completely stopped by the lines A-B or D-C and later controlled by flanking. The fire boss did not dare place too much faith in either plan but was ready to order the crew into direct attack on either line if the backfire and line had knocked down the front of the fire sufficiently to permit an effective direct attack. The plan did not work in this particular case but each temporary fire line served its main and primary purpose of materially delaying the time the fire reached the ridge G-H-I and materially shortened the width of the head of the fire when it reached this ridge road line.)

POINTS TO CONSIDER IN BACKFIRING

1. Backfiring is the most common opportunity for emergency action. Since there is usually little to lose and much to gain, chances should be automatically watched for and taken advantage of.
2. If backfiring is to be used on one or more sectors, the initial control plan should recognize it in location of lines, in timing of operations, and in equipment ordered.
3. The more advanced techniques, free-running backfire to offset poor burning condition along control lines, and echelon backfiring can solve otherwise unsolvable control problems.



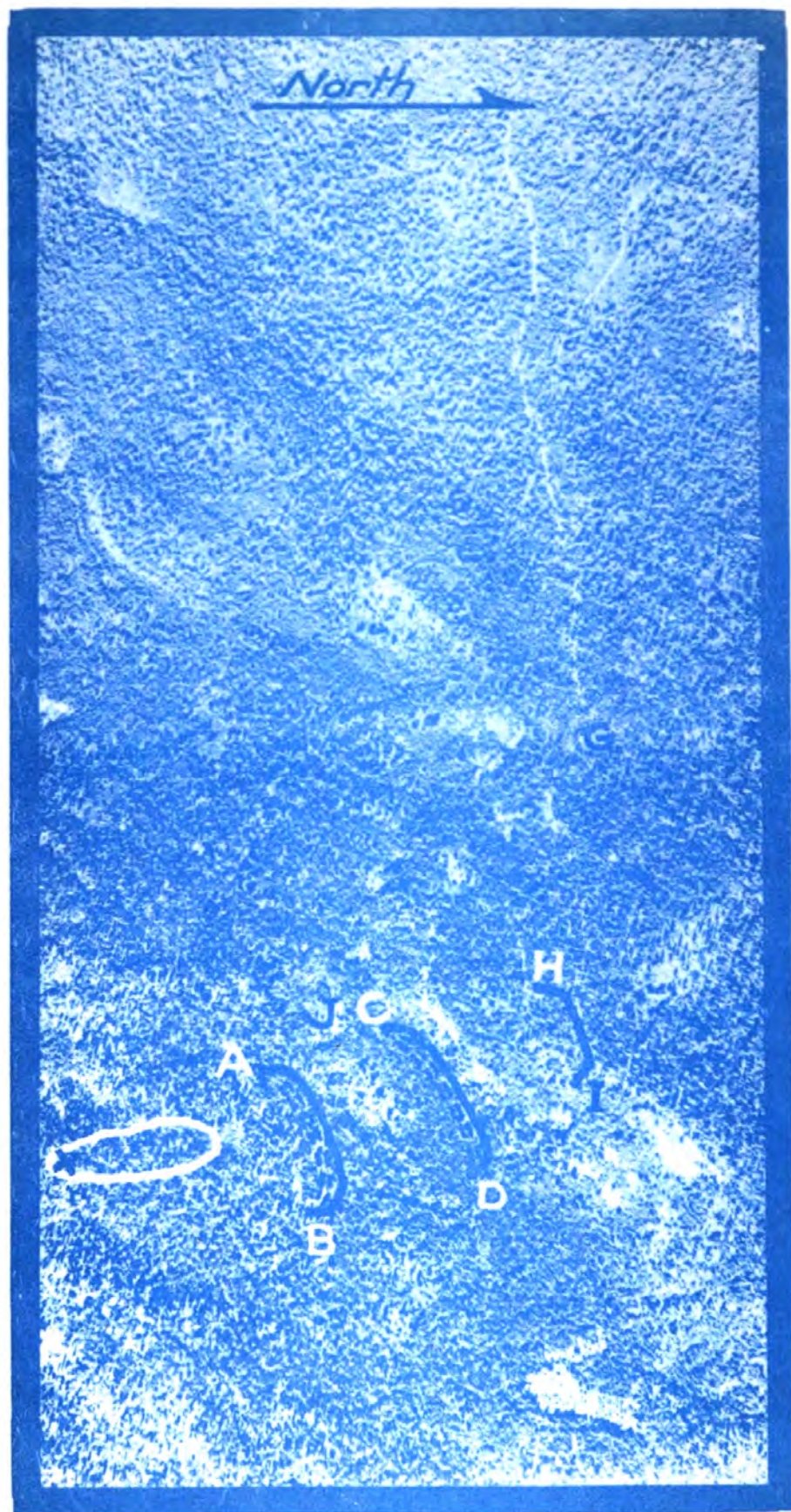


Fig. 53 Scale 3" = 1 mi

TWO-WAY ATTACK

Foreword

Not on every day, but almost constantly, the future of the world is as so uncertain that alternative courses of action must be considered for every forward situation. One is the "if" and the other is "or" and the other is "or".

In such situations, if the first course is chosen, it is possible to change line of action and either the original plan or a new one, changing radically or the original plan, may be chosen. The original plan has been lost or starting, revised, revised, revised.

Common situations in which a situation is two-way, or three-way, is carried on an illustration in the following.

TWO-WAY ATTACK

WHEN RESULT OF BACKFIRE UNCERTAIN

Problem 1

Use Figure 17

Conditions

Same as in line diagram, or given.

Solution Required

Can the change in line of action be made without loss of time or without losing contact with the I-I line of action?

Acceptable Solution

1. The odds of losing the guns are greater than 50-50, and the odds are stated in solution 1, problem 1.
2. But there is a fair chance and there is no danger to the men.
3. Start backfiring guns I-I after line construction.
4. Simultaneously start backfiring line I-I.
5. Work selected men in slope south of I-I after backfiring to the catch spots from backfiring.
6. Backfire ridge only after it is sure that a lost. Give time to see if any spots are caught and the ground is and it is lost that most starting on slope must be removed.
7. Any reasonable change in line after that can be carried out when when forces are available for a second simultaneous change in line should be taken.

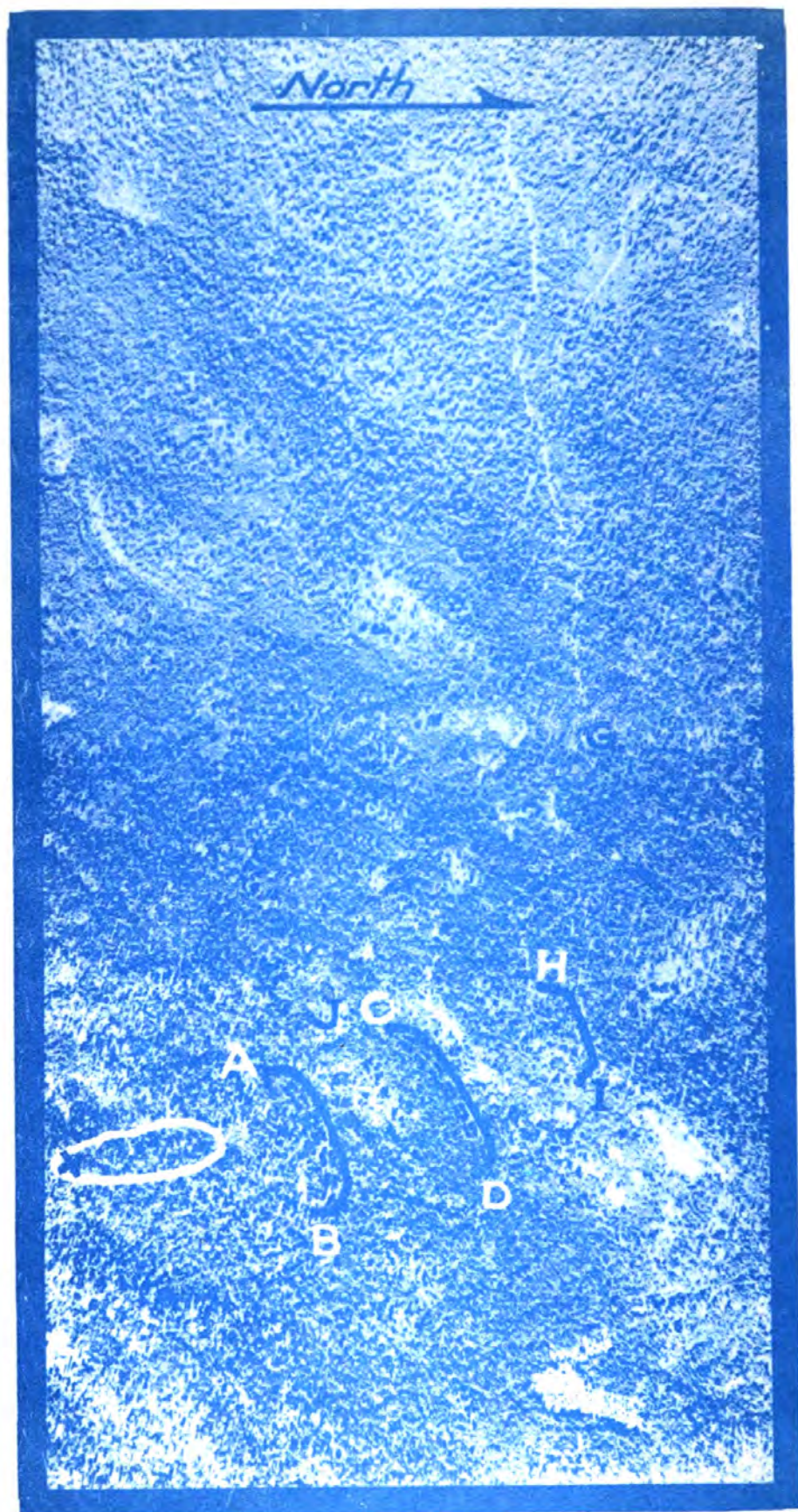


Fig. 52 Scale 2" = 1 mi

TWO-WAY ATTACK

Foreword

Not on every fire, but rather commonly, the future behavior of a fire is so uncertain that alternative courses of attack may be planned and carried forward simultaneously up to the point when final decision on one or the other is forced.

In such situations if the fire boss commits himself completely to a single line of action, and either the anticipated behavior of the fire changes radically or the planned attack fails, then valuable, often essential, time has been lost in starting a revised course of action.

Common situations in which a simultaneous two-way course of attack is carried on are illustrated in the problems.

TWO-WAY ATTACK

WHEN RESULT OF BACKFIRE UNCERTAIN

Problem 1

USE FIGURE 17

Conditions

Same as in line location, problem 6.

Solution Required

Can the chance to hold down acreage by backfiring gulch A-D be taken without losing chance to use ridge D-E-A if gulch is lost?

Acceptable Solution

1. The odds on losing the gulch are greater than 50-50, for reasons stated in solution of problem 6.
2. But there is a fair chance and there is no danger to the men.
3. Start backfiring gulch A-H after line construction.
4. Simultaneously start clearing line on ridge D-E.
5. Work selected men on slope south of A-H after backfiring to try and catch spots from backfire.
6. Backfire ridge only after it is sure gulch is lost. Give time to see if any spots are caught before giving up and if lost that men stationed on slope have been removed.
7. Any reasonable chance to save area that can be carried out safely when forces are available for a second simultaneous course of action should be taken.

TWO-WAY ATTACK

WHEN RESULT OF DIRECT ATTACK UNCERTAIN

Problem 2

USE FIGURE 24

Conditions

Same as line location, Problem 14.

Solution Required

Can the chance to hold down acreage by direct attack on slopover be taken without losing chance for probable necessity to backfire entire slope?

Acceptable Solution

1. The odds on losing the direct attack are greater than 50-50, for reasons stated in solution for Problem 14.
2. But there is a fair chance, and without danger to the men.
3. Make direct attack vigorously. Try to prevent further roll.
4. Simultaneously start preparing backfire lines that will be required if direct attack fails, F-D, E-C and D-C.
5. Start backfiring operations only after it is sure direct attack has failed. Give time to see roll cannot be caught up.
6. Any reasonable chance to save area that can be carried out safely, and when forces are available for a second simultaneous course of action, should be taken.

TWO-WAY ATTACK

WHEN FUTURE WIND VELOCITY UNCERTAIN

Problem 3

USE FIGURE 45

Conditions

Same as in change in weather, Problem 1, except

1. No prediction on increase of wind velocity, but some increase in normal expectation.
2. More manpower available at point F at 2:30 P.M. than required for plan to attack on A-B-C-D.
3. Line G-H and north portion of line F-E shown in figure apply to change in weather, Problem 1, and are not applicable in this two-way attack problem.

Solution Required

Can the chance to hold down acreage by attack on A-B-C-D be taken regardless of change in wind, without chance of losing E-F-G-H, in case line B-C doesn't hold?

Acceptable Solution

1. Frontal attack on B-C is obviously a gamble, especially if expected increase in wind velocity comes.
2. If increase does come, break will be on B-C, and this will not necessarily weaken lines A-B and C-D.
3. Start line construction B-C.
4. Simultaneously start A-B, C-D, F-G and F-E. Line F-E will be extended only so far as is necessary to prevent flanking by the main fire.
5. If B-C irrevocably lost it will be on a narrow front.
6. Stay with A-B and C-D and touch off F-G, tying in F-B and G-C after front stopped. (See item 3 under Conditions.)

POINTS TO CONSIDER IN TWO-WAY ATTACK

1. A backfire which may fail, but which has a fair chance to succeed, should be paralleled in time by construction of a second backfire line, to be used if needed.
2. Direct attack, which may fail should be simultaneously backed up by construction of a backfire line, to be used if needed.
3. A close-up plan of attack, based on current rate of spread, which may fail in part if a possible or probable increase in wind velocity takes place, should be simultaneously backed up by construction of an alternative line, to be used if needed.

MOP-UP

Foreword

The detailed techniques of mop-up, and mop-up organization, already covered in the Region 5 Guard Handbook, are substantially the same for large as for small fires. The mop-up problem characteristic of large fires is whether to use construction crews, already fatigued, or fresh crews, and to calculate mop-up needs and cut down the number of men on the line promptly to the real requirements of the mop-up job.

MOP-UP

ORGANIZATION OF MOP-UP MANPOWER AFTER CONTROL OF FIRE

Problem 1

Conditions

Region: North coast.

Time of year: Mid-August.

Time of day when fire is controlled: 4:00 P.M. (second day).

Size of fire when controlled: 1,400 ac.—2,000 ch. perimeter.

History to date: Fire started preceding afternoon at 3:00 P.M. Shift of 250 men, excluding overhead, worked on fire line construction, holding and backfiring from 6:00 P.M. to 6:00 A.M. (second day). Day shift of equal size completed line construction, holding and backfiring at 4:00 P.M. Day shift to complete shift time on line at 6:00 P.M. when night shift is ready to return to line.

Weather, current: Wind, 5 mi. per hour; relative humidity, 15%; fuel moisture, 4%.

Predicted: No change expected.

Elevation: 3,700' to 4,000'.

Topography: Moderate slope, 20-30%.

Type: Pure manzanita and chamise 5' to 7' high (no snags on or near area).

Manpower available: No additional men available except by about 200 mi. travel.

Solution Required

Manpower (mop-up) organization plan after 4:00 P.M. (second day).

Acceptable Solution

By 3:00 P.M. the fire boss realizes, from information supplied by his assistants, that all line construction, line holding and backfiring work would be completed at or near 4:00 P.M. He also realized that for mop-up work in this type he would need an average of one man per 25 ch. of line (based on his knowledge of controlled fires in this type), or a total of 80 men plus 4 line formen. (If there had been any snags on the

and the feet MBM expected to be disposed of per man day.) number of fallers needed based on number of feet MBM to be felled area to be felled he would have added to their number the estimated

The mop-up work (without snags to fell) will consist of searching the area for the occasional down logs or roots or accumulations which might be holding fire and extinguishing such, while maintaining a skeleton patrol on the fire line as long as there is a possibility of sparks crossing this line. During the night the entire mop-up crew will be patrolling established stations along the line, making certain the backfiring job was satisfactorily completed and that no hot spots remain in vicinity of line by extinguishing all those located. During the day the burned area will be systematically gridironed and worked by one-half the men on the job while the other half is on skeleton fire line patrol work on established stations averaging 50 ch. per man.

The fire boss orders 170 men of the day shift to return to camp for releasing at 5:00 P.M. (he leaves one hour safety factor). He has 20 ch. patrol stations established for the selected 80 men retained on line. He orders all but 80 of the 250 night shift released. Proportionate cuts are made in camp and line overhead. (Too often the entire crew on line is retained until the end of the shift and the full or only slightly reduced next or day shaft is kept on until late afternoon before a major cut in manpower is made with resultant heavy unnecessary expense.) With the two 80-man mop-up crews the fire boss expects to have the mop-up job completed and camp "pulled" by 6:00 P.M. (third day).

MOP-UP

ORGANIZATION OF MOP-UP MANPOWER AFTER CONTROL OF FIRE

Problem 2

Conditions

Data same as for Problem 1 except manpower. In this case additional fresh manpower to extent of 200 men are available within 20 mi. of fire by truck road.

Solution Required

Manpower (mop-up) organization plan after 4:00 P.M. (second day).

Acceptable Solution

Fire boss makes same arrangement as in Problem 1 for completion of going day shift. He releases remainder of day shift on duty (80 men) at end of shift (6:00 P.M.) and releases at once entire night shift (250 men). He orders 80 fresh men to report for line (mop-up) duty at 6:00 P.M. (second day of fire) and 80 additional fresh men to report for line (mop-up) duty at 6:00 A.M. (third day). He releases night shift of 80 fresh men at end of their first shift (6:00 A.M. third day), and expects to complete mop-up job by 12 noon on third day due to more energetic work by both fresh night crew and fresh day crew. Camp is "pulled" between 12:00 noon and 4:00 P.M. by a crew of 10 men. By use of the fresh crews the fire boss expects to reduce the manpower costs of the mop-up job (after 4:00 P.M. second day) by over 400 man hours without any loss in effectiveness of the job done.

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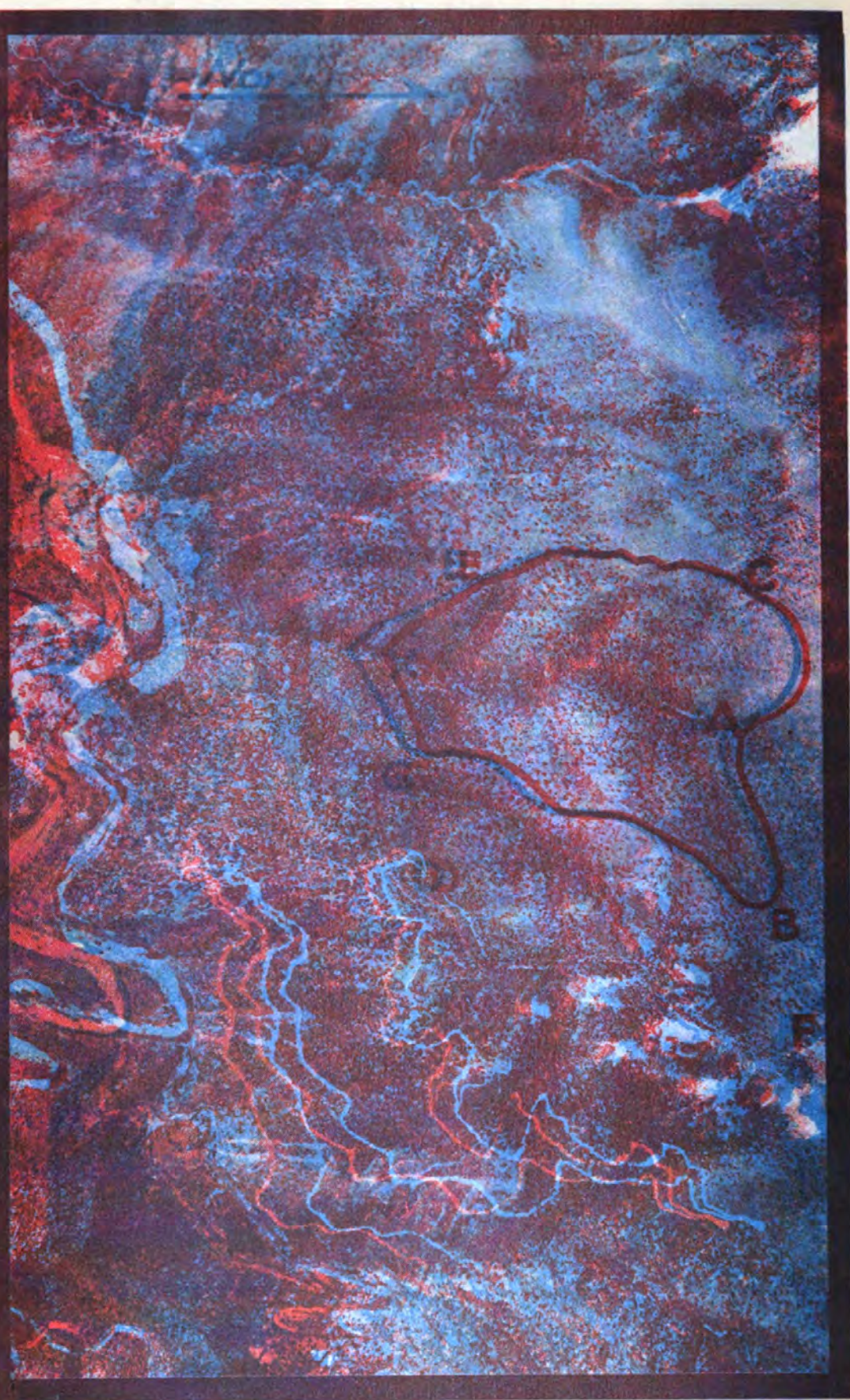
MOP-UP

POINTS TO CONSIDER

1. Estimating size of mop-up crew required is difficult because the problem varies from fire to fire in the same type. But it is feasible.
2. Estimating needs and prompt cutting down of men on the line to the correct figure determined should be done rather than retaining line construction and line holding crews merely because they are already on the line.

North →





PATROL

Foreword

A very large part of the total suppression bill goes for patrol which, in actual fact, often means more holding of tired men on the lines.

The ready availability of radio opens great possibilities for skilled use of radio sets and lookouts to supplant to a major degree the costly on-the-line system of patrol which has heretofore been needed. The planned use of horseback patrols likewise is a method of reducing costs without sacrifice of safety, which can be used more widely.

PATROL

USE OF HORSE

Problem 1

USE FIGURE 54

Conditions

Region: North coast.

Time of year: July.

Time of day: 8:00 P.M.

Size of fire when controlled: 176 ac.

Perimeter of fire needing patrol: 190 ch.

History: Fire boss and 25 men had fought fire all day and by using section of trail E-C had completed 190 ch. of line controlling fire by 8:00 P.M. Entire crew tired out. Fire within lines still sufficiently live that entire line must be patrolled during the night to prevent possible break.

Weather: Wind, 10 mi. per hour; relative humidity, 30%; fuel moisture, 6%. Wind is expected to increase to 25 mi. per hour about 6:00 A.M. next morning.

Elevation: Gulch bottom point A 1,300', ridge fire line 1,800' points B and C.

Topography: 25% slope from point A to point B; same for point C. Slope along ridge tops E-C and G-B, average 7%.

Manpower available: No additional qualified men and overhead available for night patrol because of other fires on Forest that had absorbed forces except guard at Ranger Station $2\frac{1}{4}$ mi. distance, who had been released at noon from another fire, and a nearby rancher who is often used on fires.

Special equipment available: Only special equipment available and useful are two horses at Ranger Station 2 mi. down road.

Roads and trails: Road D-F 17 ch. distant from east flank; trail along E-C west edge of fire.

Values: Uniform.

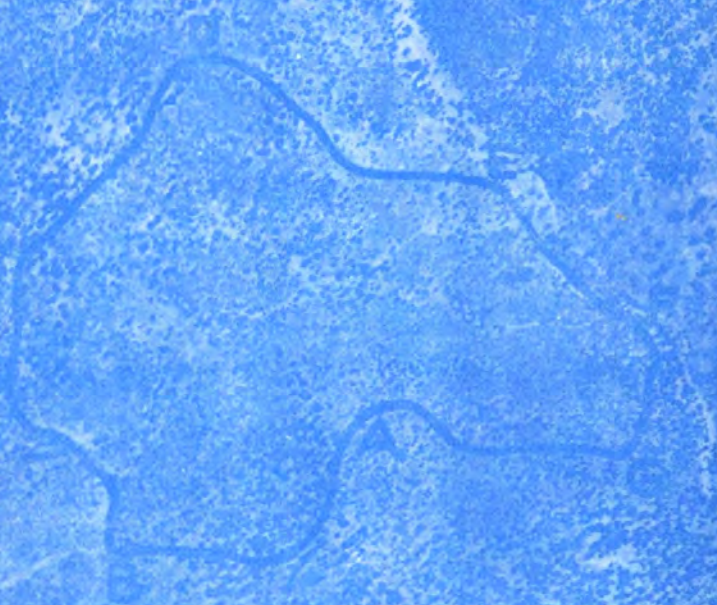
Solution Required

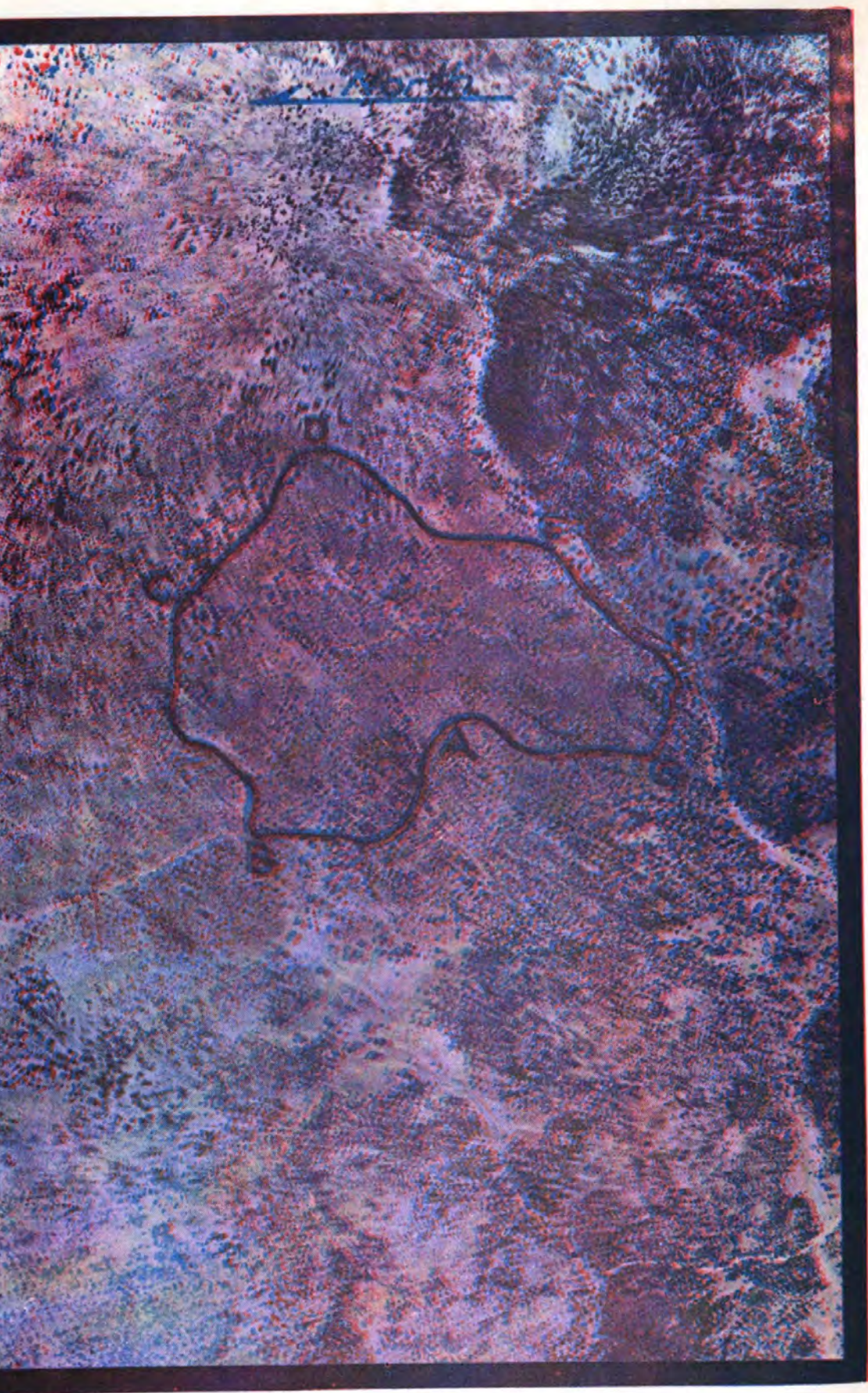
How can necessary night patrol work be done and yet have rested crew ready for work at 6:00 A.M.?

Acceptable Solution

Fire boss sizes up situation around 6:00 P.M. and radios guard to report to fire with 2 horses as near 8:00 P.M. as possible, at which time crew leaves fire line for camp and supper. Crew rests during the night while guard and the local rancher by means of horses make complete coverage of fire line $2\frac{3}{8}$ mi. during night to 6:00 A.M., when crew returns to line.

ALACRIZ





PATROL
MINIMUM PATROL THROUGH USE OF LOOKOUT
Problem 2

USE FIGURE 55

Conditions

Region: West side, Zone 1.

Time of year: Late August.

Time of day when planning begins: 6:00 P.M.

Size of fire when planning begins: 225 ac.

Perimeter of fire when planning begins: 210 ch.

History to date: Fire started 10:30 A.M. Controlled at 5:30 P.M. Most lines still hot in spots at 6:00 P.M.

Current weather: S. wind, 10 mi. per hour; relative humidity, 20%; fuel moisture, 4.5%.

Predicted weather: SW. wind, 2 mi. per hour; relative humidity, 30%; fuel moisture, 5.5%.

Elevation: 1,500' to 1,850'.

Topography: Gentle slopes. No well-defined canyons or ridges.

Rate of spread types: Grass, oak, manzanita, ceanothus, buckeye.

Manpower available: 65 men and overhead, 15 of whom have worked on line but 2 hours.

Equipment available: All tools necessary for manpower on job. 2 S-type radiophones.

Roads and trails available: Road along fire edge F-E. Trail traverses burned area F to C.

Solution Required

What plan of night patrol should be used and why?

Acceptable Solution

Fire boss selects one guard and one of the fresh fire fighters and sends them to point A, a hill from which the entire fire line is visible. These men are equipped with an S type radiophone and given instructions to keep sharp watch of fire line during entire night. Man kept on radio standby at fire camp at F on road. Remainder of force rested for a day-light start on mop-up work.

POINTS TO CONSIDER IN PATROL

1. Use of a radio net and lookouts, or horseback patrol, may often reduce greatly the cost of patrol without loss of safety.
2. Most effective organization of the patrol job varies greatly from fire to fire, but requires as high level skill as other phases of control.

PLANNING RADIO COMMUNICATION FOR A GOING FIRE

Foreword

With the constantly improving facilities that are being developed in connection with communication facilities, it is becoming increasingly easy for the fire boss to obtain "up-to-the-minute" information on which to base his plans for the control of a going fire; likewise to keep in touch with all phases of the control action as they are being carried forward. Through the use of an adequate radio network over the fire area the fire boss may quickly change his plans to care for the constantly changing control picture permitting him to take immediate advantage of breaks in his favor as well as to meet unforeseen emergencies that so often occur during the control of a complicated fire situation.

PLANNING COMMUNICATION

PLANNING A RADIO COMMUNICATION NETWORK FOR A SUPPRESSION JOB

Problem 1

USE FIGURE 56

Conditions

Region: Southern California.

Size of fire when controlled: 1,700 ac.

Topography: Broken—steep to very steep except along ridge tops on which fire breaks are located. The slopes of these breaks are moderate with some steep pitches.

History of fire as it affects problem: When controlled the fire was lined out as follows:

a. *Location of camps*

- A. Base camp supplied by trucks.
- D. Main spike camp supplied by airplane.
- E. Spike camp supplied by airplane.
- K. Spike camp supplied by airplane.

b. *Divisions and sectors*

- H - I - L Division A — 2 sectors (H-I, I-L).
- F - K - L Division B — 2 sectors (L-K, K-F).
- F - D - G Division C — 4 sectors (F-D, D-M, M-N, N-G).
- G - E - H Division E — 2 sectors (G-E, E-H).

Roads—trails: Road to base camp, point A; trail from I to L.

Solution Required

Describe the communication network that was established to handle this fire. Give reasons for selection of points and kinds of equipment used.





Acceptable Solution

1. UHF radio equipment was used to the exclusion of medium frequency equipment with the exception described below, since (1) interference from distant stations is eliminated through the use of this type of equipment; (2) it is more portable; (3) there is less local interference; (4) it was possible to set up a network of optical paths for this type of equipment, and (5) battery drain is low.

Two medium frequency stations were established: namely, one portable M type radiophone was established at *point A*, the base camp, and one SPF type radiophone at *point D*, the main spike camp. These sets were installed to effect communication between the base camp and the main spike camp, optical paths not being possible for this purpose. It was highly desirable to permit direct communication between these two important points of operation.

2. *Communication center*

A communication center was established at point B. This point was selected, since it had optical paths with points E, D, and C, the field stations set up to provide communication outlets for line workers.

This station was equipped with one T type radiophone and one telephone. The telephone was connected with the base fire camp, point A, by emergency wire to permit transmission of field messages to the fire camp; likewise to receive messages from the base camp for transmission to the other field stations.

3. *Field Stations*

C—equipped with one SV type radiophone to provide a communication outlet for sectors H-I, I-L, L-K, and K-F and to permit communication with stations E and B.

E—equipped with one SV type radiophone to provide a communication outlet for sectors E-H, E-G, and G-N and to permit communication with points C, B and D.

D—equipped with one SV type radiophone to provide a communication outlet for sectors N-M, M-D and D-F and to permit communication with points E and B. As previously stated this station was equipped with one SPF type radiophone to provide direct communication between this point and the base camp at point A.

4. *Line sets*

Each division and sector boss was equipped with one S type radiophone so he could communicate with his local field station as the need arose. Each ground scout and line inspector was also provided with one S type radiophone for the same reason. Likewise the fire boss.

5. *Communication schedules*

Written schedules were established to reduce the possibility of interference. Each man operating a radio had a copy of this schedule at hand for reference so he knew when the channel was open for him if he wished to send a message.

6. *Summary of communication equipment for this fire*

- a. Base camp—1 M set—1 telephone.
- b. Communication center—1 T set—1 telephone.
- c. Field stations E, C, and D—1 SV set each.
- d. Main spike camp D—1 SPF set.
- e. 4 division bosses, 10 sector bosses—14 S sets.
- f. Scouts, line inspectors and fire boss—1 S set each.

Totals excluding line inspectors and scouts:

1 M set
1 SPF set
15 S sets
3 SV sets
2 Portable telephones

POINTS TO CONSIDER IN COMMUNICATION ON A FIRE

1. Use of UHF equipment to greatest possible extent.
 - a. To eliminate interference.
 - b. Since they are highly reliable and portable.
 - c. Since they are easily and quickly installed.
2. Use of medium frequency equipment only where UHF equipment will not give the coverage required because of lack of optical paths.
3. Provision of communication for all higher overhead positions (sector bosses and higher).
4. Do not replace available telephone service with radio.

THE FIRE AS A WHOLE

Foreword

Each of the preceding problems in this handbook is designed to illustrate and provide practice in considering one by one the individual major elements of the entire control process.

For the complete control of a fire all of these elements must be weighed and applied in their proper sequence.

This more complex action, required when many elements must be considered, correlated and combined on the same fire, is illustrated by the following "Overall" problems.

In addition to working through these problems step by step as they are set up valuable experience and practice will be obtained by reworking the problems with certain elements of weather, cover, topography, manpower or facilities changed.

Use of the outline "Routine for Overall Suppression Planning by Fire Boss" which follows the overall problems will provide for considering all elements in their proper sequence. Setting up and solving original problems based on (1) an actual fire which has occurred in some specific location, or (2) of an imaginary fire in a difficult or hazardous piece of country will be found invaluable in developing facility in planning action or in thinking out beforehand what action would be taken in a given location.

OVERALL PROBLEM

Problem 1

USE FIGURE 57

Conditions

Region: West side, Zone 1.

Time of year: Mid-July.

Time of day when planning begins: 1:00 P.M.

History to date: Started at 11:00 A.M. Reported by Lookout at 11:30 A.M. to be burning east of river. Fire boss reached point P on road F-P-G at 1:00 P.M. No forces other than single Guard on fire, due to other fires. He is watching fire to keep it from crossing river.

Weather: W. wind, 8 mi. per hour; relative humidity, 15%; fuel moisture, 3%. Change predicted: Sharp rise in relative humidity; wind to die down commencing 6:00 P.M.

Elevation: Origin 4,500', ridge M-N average 5,100'.

Manpower equipment: Due to other fires, none can be furnished until 4:00 P.M. Then all needed.

Solution Required

- a. Determine in order of priority the major decisions the Fire Boss must make when planning control of this fire.
- b. Develop a complete plan for controlling the fire, giving reasons for each step in the plan.

Acceptable Solution

NOTE: Fire Boss knows country intimately; consequently, since he can see fire and adjacent area, no scouting required.

1. *Factual data*

a. *Lay of the fire*

Fire Boss from point P sees that the fire is burning east of the river; that it has two heads, namely, A and B, A being 22 ch. up the slope with head B approximately 18 ch. up the slope. Fire approximately 20 ch. wide from head A to head B. Fire burning both sides of small drainage.

b. *Topography*

Slope steep along river except in mouth of creek where slopes are moderate. Slopes are moderate in basin in which fire is burning.

c. *Accessibility*

No roads or trails where fire is burning.

d. *Period fire has been burning*

From Lookout reports fire estimated to have started 11:00 A.M. At 1:00 P.M. it had been burning 2 hours.

2. *Probable behavior*

a. *Rate of spread to date*

1. 0 dimensions—11:00 A.M. (time of start).

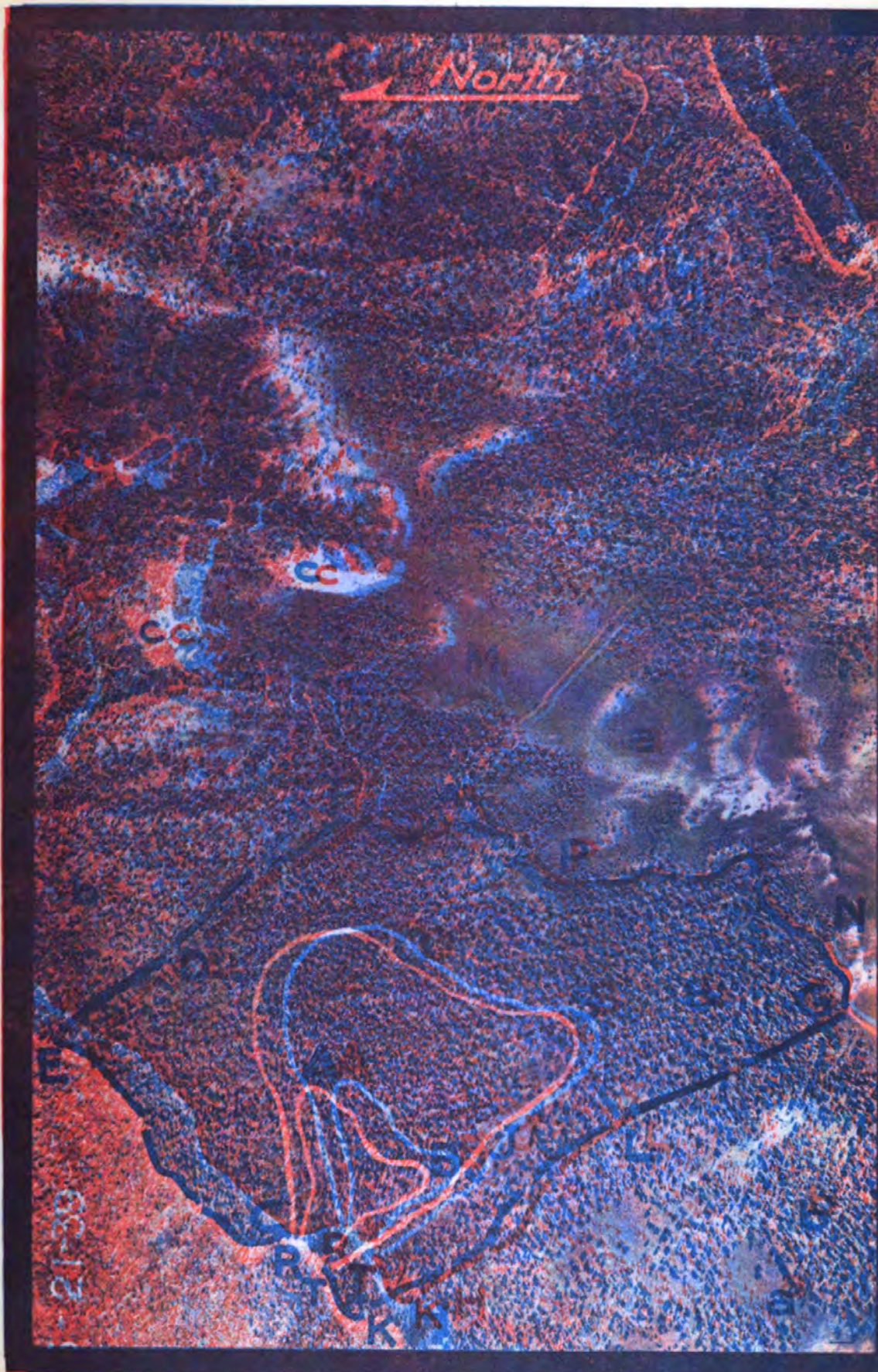
2. 22 ch. by 15 ch. by 18 ch. long and 20 ch. wide at its head. Base of fire about 5 ch. wide. (Arrival of fire boss 1:00 P.M.) From these calculations the fire has an estimated perimeter of 60 ch. or a rate of perimeter increase of 30 ch. per hour ($60 \div 2$).

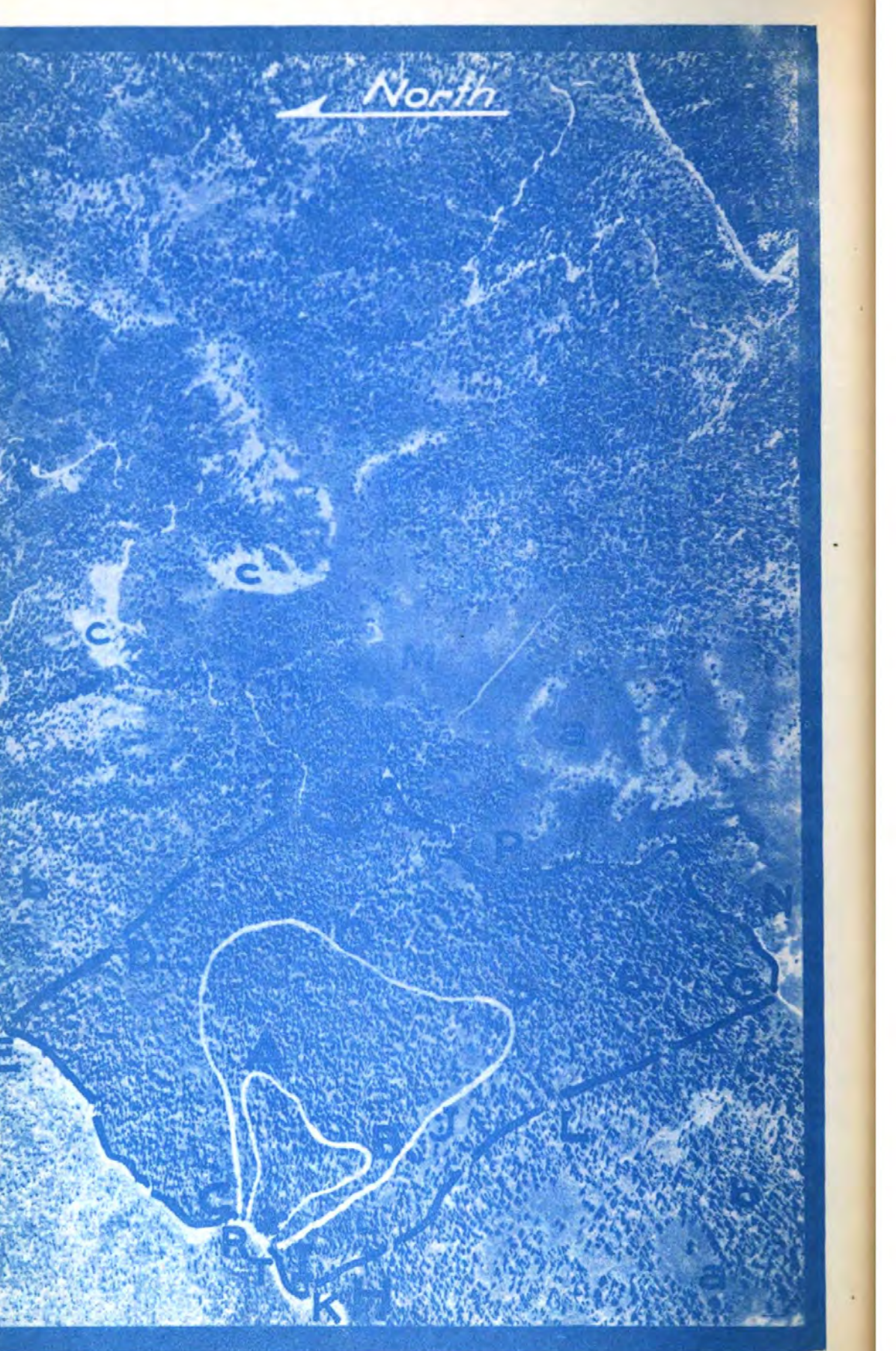
b. *Type in which burning*

Through observation he determines that the fire is burning in a mature closed stand of ponderosa pine timber containing scatter reproduction and a few small patches of brush.

c. *Slope on which burning*

Through observation he determines that the fire is burning in a small basin of moderate slopes with drainage to the southwest.





d. *Conditions ahead*

1. *Weather* is predicted to continue the same for the next five hours; W. wind, 8 mi. per hour; relative humidity, 15%; fuel moisture, 3%. After 6:00 P.M. the wind will die down, relative humidity and fuel moisture will sharply increase. (Obtained from dispatcher before leaving for fire.)
2. *Rate of spread types* uniform except dense manzanita brush field on ridge above road F-P-G and along spur ridge G-H.
3. *Slope ahead* of fire averages moderate to top of ridge M-N, slightly steeper immediate vicinity of this ridge. Slope from spur ridge D-C to river steep (55%).
4. *Barriers*. Only barriers are at area c. Not important.
5. *Special hazards*. Dense manzanita brush field 50 ch. southeast of fire.

e. *Calculated position, perimeter and area* at 4:00 P.M. when control forces can be made available.

1. *Position*

Forward progress averaged 20 ch. in 2 hours or 10 ch. per hour. In two more hours (4:00 P.M.) fire will be 20 more ch. up slope. In two hours the head of the fire obtained a width of 20 ch., consequently in two more hours, due to the effect of the topography in the basin, it may be expected to increase in width at the same rate or be 40 ch. wide at the head at 4:00 P.M.

2. *Perimeter*

From 11:00 A.M. to 1:00 P.M. the fire had a perimeter increase of 30 ch. per hour. Conditions remaining the same, it is expected to have a perimeter of 150 ch. at 4:00 P.M. (5×30).

3. *Area*

Calculated to be 100 ac. See figure R-O-S-T-R for calculated location of fire at 4:00 P.M.

f. *Calculation of control line location*

1. *Consideration of control line location*

A short way southeast of road F-P-G the type changes from timber to heavy manzanita brush. If the fire gains a foothold in this brush the resistance to line construction will increase materially (from 1.4 ch. per man-hour for timber to .5 ch. per man-hour; for trailbuilder unit, from 24 ch. per trailbuilder hour to 10 ch. per trailbuilder hour). Thus it is important that the fire be prevented from entering this area.

The fire, it is estimated, will reach the break in type at approximately 6:00 P.M. Therefore, the fire line to head the fire must be completed prior to this time.

The fire under present rates of spread will reach ridge F-D at its mid-point by about 5:30 P.M. Thus this side of the fire must be stopped by that time to prevent it from gaining a foothold in the basin to the northeast, since once it gains a foothold in this basin it will be necessary either to carry a line down the main draw in this basin or accept an undercut line. The former would cause a large increase in area; the latter would have the undesirable undercut feature connected with all such lines.

The southwest flank of the fire, it is calculated, will have burned beyond ridge I-J to the southwest and consequently it cannot be used. The ridge to the southwest (G-H) is covered with large patches of heavy brush which would present construction and backfiring difficulties if it was used. Draw L-K and spur ridge G-L offer possibilities, since they are both traversable by trailbuilders, the type present will permit more rapid line construction, and backfiring will be easier due to the "uphill" nature of the job as compared to ridge G-H.

The northwest flank of the fire will have approached within about 5 ch. of ridge D-C by 4:00 P.M. Though this ridge is ideally located for control purposes, the fire will be so close by the time suppression forces arrive that time to construct and hold this flank along this ridge is not available. There are no serious interlocking points along the river; hence the river can be used as the north line, dropping off ridge F-D wherever convenient. If this line is used to control the fire along its northeast flank an RD-7 trailbuilder can construct line from ridge F-D into river, since the slope does not exceed 55%.

2. *Selection of control line location*

a. *Head of fire*: F-P-G is selected for the following reasons:

1. Head of fire too hot for direct attack.
2. Fire will be two hours away from this line at 4:00 P.M., leaving ample time to backfire the road and have it in shape to hold the fire.
3. Will prevent fire from entering brush field to southeast where rate of spread and resistance to line construction much higher.
4. Economical since road can be used entire distance.
5. Will prevent fire from entering second major drainage.

- b. *Northeast flank*: Ridge F-D-E is selected for the following reasons:
 1. East head too hot for direct attack.
 2. To keep fire out of large basin to east.
 3. To prevent undercut line from being used, which would be necessary once fire entered basin.
 4. Trailbuilder can be used without difficulty.
 5. Will shorten line considerably over F-D-C if D-C of this line possible (50 ch. against 85 ch.).
 6. D-E section of this line more certain than D-C since plenty of time to construct and backfire former; doubtful if sufficient time for latter.
 7. Line easier patrolled along river E-C—water available—not the case along D-C.
- c. *Southwest flank*: G-L-K selected for following reasons:
 1. Flank of fire I-J will not cross the draw L-K prior to the time line can be constructed, due to spread on flank slowing down going into this draw.
 2. Trailbuilder can be worked to advantage.
 3. Backfiring uphill easier and more certain.
 4. South head of fire sufficiently far north of point G to permit construction and backfiring of line G-L before fire reaches it.
 5. Will eliminate difficult construction and burning-out job that would be the case if ridge G-H is selected.
- d. *Northwest flank*: K-E selected—along river, easily burned out, held and patrolled.
- g. *Timing for different lines* (from 4:00 P.M.).
 1. Line F-P-G completed within 2 hours since—
 - a. Fire will reach it by that time.
 - b. Relative humidity predicted to sharply increase during night.
 2. Line F-D completed within 1½ hours since
Fire will reach it by that time.
 3. Line G-L-K completed within 1 hour since
Fire will almost surely reach it within that time.
 4. Line D-E completed within 3 hours since
To complete it later would be difficult due to increase in relative humidity.

5. Line E-K completed within 3 hours since

To complete it later would be difficult due to increase in relative humidity.

Thus the control lines must all be completed and burned out by 7:00 P.M.

h. *Calculation of manpower and equipment needed*

1. *For construction*

- a. Road F-P-G = 90 ch. No construction—0 men.
- b. F-D = 35 ch. $1\frac{1}{2}$ hours to complete. At 1.4 ch. per man-hour for this type = $35 \div (1.4 \times 1.5) = 17$ men. If one trailbuilder is used it can construct this line in $35 \div 24 = 1$ hour 27 min. A trailbuilder is selected in lieu of the men since as soon as it has completed this line it can continue with line D-E (15 ch.) completing it by 6:00 P.M.—well ahead of the time requirements.
- c. E-K = 50 ch. No line construction—0 men.
- d. G-L-K = 75 ch. 1 hour to complete at 1.4 ch. per man-hour for this type = $75 \div 1.4 = 54$ men. Since it would take 3 trailbuilders to handle this job in the time required, none are ordered for this sector.

Total line construction requirements

Man-power 54

RD-7 1, plus operator and 2 swamper.

2. *For backfiring*

- a. Road F-P-G = 90 ch. Fire must be burned back at least 5 ch. to hold head of fire. Requires that backfire be completed within one hour. 2 men can backfire 30 ch. per hour. $2 (90 \div 30) = 6$ men required.
- b. F-D = 35 ch. Backfire must be completed within 1.5 hours for same reason or 2 men for backfiring.
- c. D-E = 15 ch. Backfire need not be completed for 3 hours; however, since line F-D will be backfired by 5:30 P.M. and D-E will be constructed by 6:00 P.M., the men assigned backfiring on F-D should continue to E as soon as they complete F-D. Thus no additional men needed to backfire D-E.
- d. G-K = 75 ch. At rate of 2 men, 30 ch. per hour, it will take $2 (75 \div 30) = 5$ men.
- e. K-E = 50 ch. Since this line need not be completed until 7:00 P.M., the men who handled the backfire along lines F-E and G-K can be assigned to backfire this line to complete it well within time limits.

Total backfiring—13 men.

3. *For holding*

- a. F-G = 90 ch. At 3 men for 10 ch. for 3 hrs. = 27 men.
- b. F-E = 50 ch. At 3 men for 10 ch. for 3 hrs. = 15 men.
- c. G-K = 75 ch. At 3 men for 10 ch. for 3 hrs. = 22 men.
- d. K-E = 50 ch. (reduced to 1 man per 10 ch. for 2 hours due to the wind being favorable) = 5 men. Five of the men constructing line G-K can be assigned the holding job along this sector since G-K will be completed before work is initiated on K-E.

Total holding—64 men.

i. *Sector of first attack*

There is no one sector of first attack. There are three such sectors, as follows:

1. Start at point F with trailbuilder, constructing line to E. Start simultaneously at point G with hand line to L. Simultaneously, start backfires from F towards E, from F towards G, from G towards F, and from G towards K. Lastly, backfiring up river from K and down river from E.

j. *Camp location and size*

1. At point c since water in draw to southwest on road and safe since area is barren; also only 40 ch. or 10 minutes' drive to point F and 20 minutes' drive to point G.
2. Camp for 150 men, camp organization required.

k. *Fire control organization*

1. Sectors

F-G
F-E-C
G-K-C.

2. Summary—manpower, overhead, machinery, equipment each sector.

a. Sector F-G.

1. Construction—0 men.
2. Backfiring—6 men—1 crew boss.
3. Holding—27 men—3 crew bosses.
4. One sector boss.
5. Backfiring equipment—hand tools.

b. Sector F-E-C.

1. Construction—1 RD-7—1 operator—2 swampers.
2. Backfiring—2 men.
3. Holding—15 men—2 crew bosses.
4. One sector boss, one tractor boss.

5. Backfiring equipment—hand tools.

NOTE: Men for backfiring E-C to be obtained from F-E when backfiring completed along this line. Men for holding obtained from line construction crew G-K when line construction completed along this line.

c. Sector G-K-C.

1. Construction—54 men—5 crew bosses.

2. Backfiring—5 men—1 crew boss.

3. Holding—22 men—3 crew bosses.

4. One sector boss.

5. Backfiring equipment, hand tools.

NOTE: Men for backfiring and holding K-C obtained from backfiring and line construction crew when G-K completed.

Fire boss orders above 133 men, 19 line overhead, and equipment to report to F by 4:00 P.M. and adequate camp organization to report to c. In the meanwhile guard on river instructed to hold fire from crossing to northwest of river.

l. *Mop-up*

Since it is difficult to do effective mop-up work at night, all mop-up will be left for the next day beginning at 5:00 A.M., resting the men who would otherwise be used.

m. *Patrol*

F-G. Men on this sector will complete line-holding by 9:00 P.M. One crew of 5 men and one crew boss will be left to patrol the line during the night. The remainder, 28 men plus 3 crew bosses, will be released to camp for rest.

F-E-C (K). Men on this sector will complete line-holding by 10:00 P.M. One crew of 4 men and one crew boss will patrol line F-E; one crew and 3 men will patrol line E-K; remainder, 12 men, one tractor boss, also trailbuilder operator, released to camp for rest.

G-K-C. Men on this sector will complete line-holding by 9:30 P.M. Two crews, 6 men each, and 2 crew bosses will patrol line F-K (the remainder of line to C being handled by men on sector F-E-C. Remainder—69 men, 7 crew bosses—returned to camp for rest. Sector bosses stay on line during night. This leaves for mop-up next day 109 men, 10 crew bosses, one tractor boss and one trailbuilder operator.

3 sector bosses will have to be ordered for the day shift to handle mop-up work.

Forces will be demobilized as rapidly as need for mop-up and patrol work decreases.

MANPOWER NEEDSWork Sheet for Determining Manpower, Specialist, and Overhead Needs to
Control Fire During One Burning Period

~~ITEMS~~									TOTALS
Sectors	F	G	F-E	C	G-K	C			
Sector Boss		1	1		1				3
Crew Bosses		4	2		9				15
Fire Fighters		33	19		81				133
Fallers									
Operators			1						1
Trailbuilders			1	RD-7					1
Truck-Tank									
Port. Pump									
Messengers									
Cat. Boss			1						1
Division Boss									
Line Inspectors									
Camp Bosses							1		1
Transportation Men									
Packers									
Radio Operators									

NOTE: Similar forms may be used for
determination of tools, equip-
ment, and supplies needs.

Forest _____

Name of Fire _____

Date _____

Signature _____

OVERALL PROBLEM

DETERMINE THE METHODS USED IN SETTING UP ACTION TO
CONTROL A FIRE

Problem 2

USE FIGURE 58

Conditions

Region: West Sierra.

Time of year: Late September.

History of fire: Fire estimated to have started at 1:30 P.M., reported by Lookout at 2:00 P.M.; estimated size at this time to be 2 ch. by 6 ch.; one tanker and crew of 5 men arrived at 2:20 P.M., at which time the tank truck foreman reported by radio that the fire was about 10 ch. long and 3 ch. wide, was spreading with very hot head in heavy manzanita brush east of road, that they would be unable to control fire since too dangerous to push hose line through heavy brush to reach head, that they would hold fire from crossing road to the west. Dispatcher sent a fire boss in and immediately began mobilizing fire fighters, equipment and overhead. At 2:40 P.M. Lookout reported the fire was smoking up badly and that the crew appeared to be losing the battle; size estimated to be 14 ch. long by 5 ch. wide. Fire boss arrived at point G on the road at 3:00 P.M.

Weather: Wind west to southwest, 6 mi. per hour; relative humidity, 18%; fuel moisture, 4%.

Solution Required

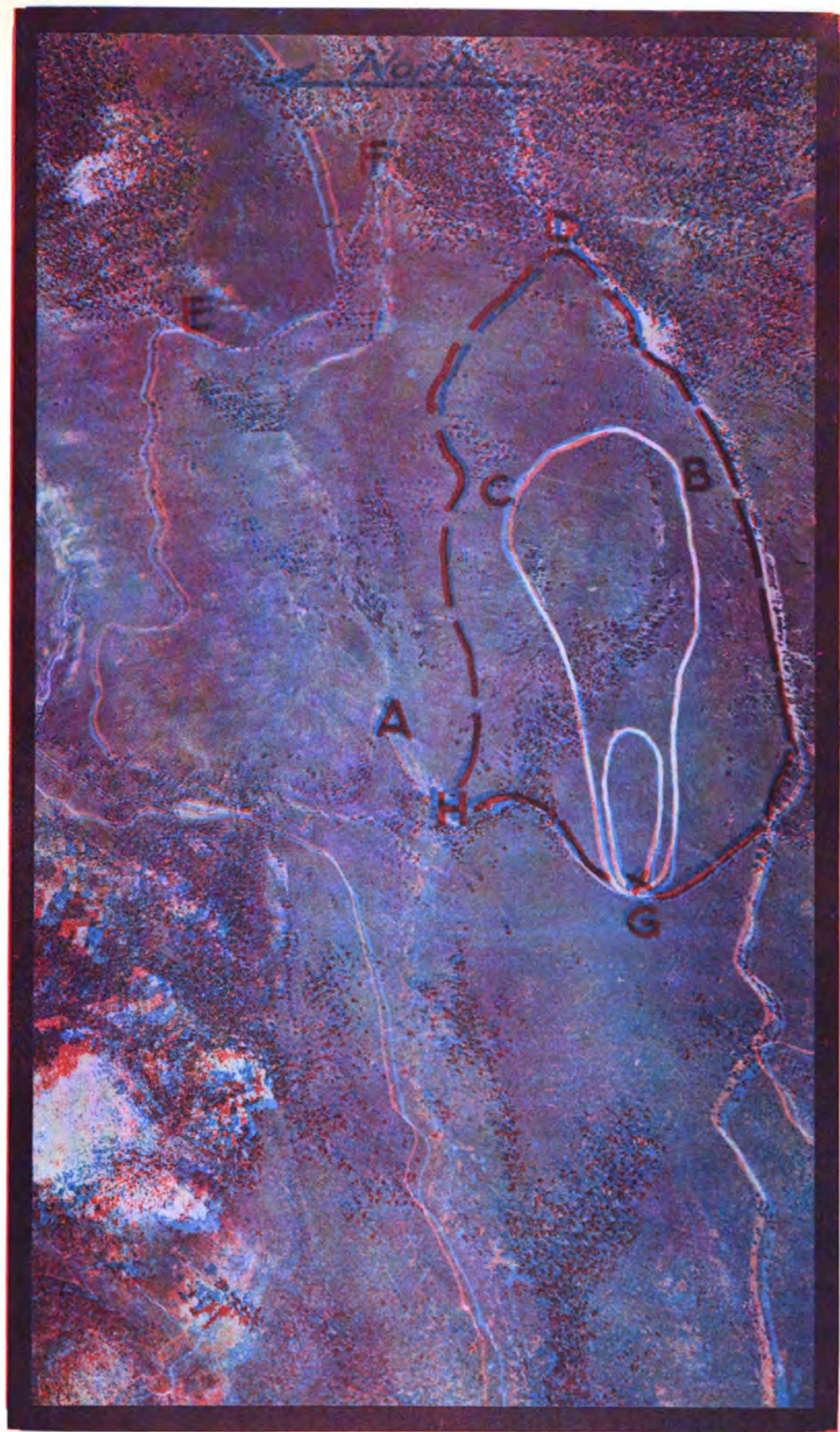
Show step by step how the fire boss solved the problem of controlling the fire.

Acceptable Solution

1. *Factual information*

When the fire boss arrived on the fire he has certain known facts that he can use to his advantage. These are:

- (a) *Location of fire.* Fire is located on a high plateau, slopes are gentle over the fire area generally, except to the north of ridge H-D, which is steep into Dry Creek F-A.
- (b) *Accessibility.* By roads throughout the area.
- (c) *Time required to mobilize forces:* According to the fire plan he knows the dispatcher cannot have adequate forces and the necessary heavy equipment on this fire until 6:00 P.M.
- (d) *Length of time fire has been burning.* From Lookout reports he knows fire has been burning approximately 1½ hours at 3:00 P.M.





2. Probable behavior

(a) Rate of spread to date

1. 0 dimensions 1:30 P.M. (time of start).
2. 6 ch. $\times$ 2 ch. 2:00 P.M. (time of discovery).
3. 10 ch. $\times$ 3 ch. 2:20 P.M. (arrival initial attacking forces).
4. 14 ch. $\times$ 5 ch. 2:40 P.M. (second report by Lookout).
5. 18 ch. $\times$ 7 ch. 3:00 P.M. (arrival fire boss).

Thus the rate of spread from origin to 3:00 P.M. is at the hourly rate of 33 ch. perimeter and 12 ch. along the axis.

- (b) *Type in which burning.* Through observation he determines that the fire is burning in heavy manzanita.
- (c) *Slopes on which burning.* Through observation he determines that the fire is burning along a gentle slope rising to the east.
- (d) *Conditions ahead*

- (1) From weather report obtained from the dispatcher before leaving, he has information that: (a) the wind would change direction coming from the east to northeast by 7:00 P.M. and by 8:00 P.M. would have a velocity of approximately 6 mi. per hour; (b) the relative humidity and fuel moisture would slowly increase during the night, rising to 31% and 5.5%, respectively, by midnight.

He is unable to see ahead very far so takes a quick trip along road G-D and finds:

- (2) That the type remains constant for a distance of one mile east of the fire where there is a slight change due to some scattered patches of mature ponderosa pine. Due to the brush mixed in with the timber the line construction difficulties and rate of perimeter increase would remain about the same.
- (3) No change in slope ahead of fire materially affecting control action.
- (4) *Barriers.* No natural barriers—roads surrounding area partial barriers if manned.
- (5) *Special hazards.* None to consider.

Fire boss returns to point G via road D-E-G.

- (e) *Calculated position area and perimeter when forces arrive at 6:00 P.M.* (period they will be available).

- (1) When the fire boss arrived the fire was approximately 18 ch. long by 7 ch. wide. The perimeter is approximately 50 ch. or 33 ch. increase per hour. Forward advance is at the rate of 12 ch. per hour. See figure for location of fire at 3:00 P.M.

(2) By 6:00 P.M. the fire, because of no appreciable change in type, topography, and weather conditions, will be:

(a) Perimeter (1:30 P.M. to 6:00 P.M. = 4.5 hours) $\times$ rate of spread per hour (33 ch) = 148 ch. perimeter.

(b) Forward progress is 4.5 (time interval) $\times$ 12 (forward spread) or 54 ch. See figure for calculated location of fire at 6:00 P.M., lines G-B-C-G.

(f) *Calculation of control line location.*

1. *Direct versus indirect attack.* The fire boss estimates that one man can construct but .5 of a ch. per man-hour in this type of cover; likewise a heavy tractor trailbuilder unit can construct but 10 ch. of line per hour. With the fire making perimeter at a rate of 33 ch. per hour, it would take 66 men or 3+ trailbuilders to keep up with this rate of perimeter increase. In addition sufficient men must be placed on line B-G to have it completed by 7:00 P.M. when the wind will change to come from the east to the northeast. This will take, figuring 50 ch. on this side, 100 men for line construction and an additional 20 men for holding. If this line is to be constructed with trailbuilders it would take 5 trailbuilders, figuring on a basis of 10 ch. per hour for each trailbuilder. He knows from experience that it would be impossible to work this many units on this short section of line to get the job done by 7:00 P.M. If direct attack is made it would be very costly and doubtful of success. Direct attack is eliminated from further consideration.

2. *Selecting the location of the line.* When direct attack was eliminated as a possibility, the fire boss listed the factors that would prove of aid to him in the control of fire using indirect attack.

a. *Roads.* G-D, G-A, D-E-A.

b. *Gulch.* F-A.

c. *Ridge.* H-D.

Road G-D would make a good control line since it is topographically located for control purposes, can be easily held and would not result in a greatly increased burned area. This road is chosen as a tentative location to control flank G-B. For the same reasons road G-H-A may be used to control the heel of the fire. It is chosen as a tentative location. *Road D-E-A* is eliminated as a possibility since, weather conditions changing at 7:00 P.M., the fire will not press him to use it.

Gulch F-A may be a possible control line to stop the north flank of the fire but it would result in increased area and a

long control line along this flank. Also the wind will switch from west and southwest to east and northeast by 7:00 P.M., which will keep what is now the head from moving forward very rapidly.

Ridge D-H. Ridge D-H, though not prominent, is well defined. The fire will not reach this ridge by 7:00 P.M. and when the wind changes direction spread towards this ridge will be practically stopped, leaving all the time needed to construct this line before the next morning. This ridge is selected as a tentative control line, completing the location of line around the fire.

(g) *Timing for different lines.*

1. Control work along road H-G-D must be completed by 7:00 P.M. when the wind changes.
2. Control work along ridge line D-H need not be completed as soon as along H-G-D since when the wind changes what is now the head will become the heel and flank C-G will cool down greatly and will not spread. The fuel moisture is expected to rise, making it difficult to backfire this line unless completed by 12:00 midnight. Hence this line must be completed by 12:00 midnight.

(h) *Calculation of line construction job and manpower needed.*

1. Road H-G-D = 140 ch.—0 men needed for construction.
2. Ridge D-H = 85 ch. at .5 ch. per man-hour and with 6 hours to go it will take approximately 30 men. At 10 ch. per hour for an RD-7 trailbuilder unit it will take at least two trailbuilders to construct this section of line by midnight (actually by 10:15 P.M.). Trailbuilders are chosen in place of the men. Thus only two men to swamp for each trailbuilder in addition to the operators are all that are required to construct control lines on this fire.

(i) *Calculation of manpower requirements for backfiring.*

1. In this type of country 2 men can string backfire at the rate of 40 ch. per hour. For road (H-G-D = 140 ch.), which must be backfired in 1 hour, it will take 7 men. For ridge D-H—85 ch. to be completed by 10:15 P.M., when two trailbuilders will have completed construction, will not require any additional men since the backfiring crew on road H-G-D can do this. Total backfiring—7 men.

(j) *Calculation of manpower requirements for holding.*

1. Road H-G-D = 140 ch.—at 8 men per 10 ch. for 4 hours = 112 men (all these men will not be needed immediately after 6:00 P.M.).

2. *Ridge D-H* = 85 ch.—since the wind along this flank will be favorable when burning out is done, the number of men per 10 ch. for holding can be reduced to 2, using this figure gives 17 men for a period of 4 hours. Total manpower for holding—129 men.
- (k) *Sector of first attack.* Attack must be made starting at point H and proceeding along road H-G-D, to be completed in *one* hour; this must be done to have this sector burned out before the expected wind change.
- (l) *Camp location.* Point D—has water, fire readily accessible from it is safe and can be serviced by road.
- (m) *Fire control organization.*

1. *Sectors H-G-D and H-D.*

- a. Manpower, machinery, overhead each sector.

Sector H-G-D: 119 men

11 crew bosses
1 backfiring boss
1 sector boss
hand and backfiring equipment and
one tank truck (already on job
with initial attack crew)

Sector H-D: 17 men

2 trailbuilder operators
4 swamper for trailbuilders
2 crew bosses
1 sector boss
(No backfiring crew is set up for
this sector since the backfiring crew
on sector H-G-D will handle the
job on this sector.)

Although all the men will not be needed immediately, they are ordered since within the hour all will be doing effective work. During the interim men not needed can set up camp.

- b. *Sequence of operations*

Sector H-G-D, 6:00 P.M. Start at point H with the burning-out operation proceeding along road to point D to reach this point by 7:00 P.M.

Sector H-D, 6:00 P.M. One RD-7 trailbuilder to start at point H, working along ridge toward point D. One RD-7 trailbuilder starting at point D, working along ridge towards point H, planning to join up with other trailbuilder by 10:15 P.M., 17 men to hold backfire at point H from crossing tractor line, using "stalling" lines if necessary to do this.

Sector H-G-D, 7:00-10:00 P.M. Backfire should be completed to point D along road. Have the 7 men burning-out crew continue backfire along ridge D-H, planning to complete this job by 10:15 P.M. Remainder of men for holding until 10:00 P.M., when all men except 2 crews held for patrol (including tank truck) should be released to camp for rest.

Sector H-D, 7:00 P.M. to 6:00 A.M. At 7:00 P.M. release all but one crew of men holding backfire along H-D and move them to point D to follow up and hold line along D-H as burning proceeds. Hold men on this line all night except backfiring crew who may be released at 10:30 P.M.

- (n) *Mop-up.* No mop-up needed.
- (o) *Patrol.* Men who were released at 10:30 P.M. the night before can handle patrol, which should require only a light force since with a tanker available 1 man per 15 ch. of line along road H-G-D and 1 man every 5 ch. along ridge line D-H will be about all that are required. Remainder of men would then be released from the fire.

Following these calculations fire boss contacts dispatcher and requests him to dispatch men and equipment as calculated above.

2. *Calculation of control line location.*

- a. Actual line locations on ground.
 - (1) Where direct attack? Where backfire?
 - (2) To utilize barriers?
 - (3) To shorten lines?
 - (4) To get easy construction and holding?
 - (5) To protect higher value areas?
 - (6) To protect men?
 - (7) To avoid high hazard areas?
 - (8) To avoid undercut lines?
 - (9) To facilitate use available tractor or tanker?
 - (10) To facilitate backfiring when that is to be done?

3. *Calculation of line construction job.*

- a. Approximate length of line in different types?
- b. Approximate overhead and manpower requirements?
- c. Can tractors be used? On how much line?
- d. Can tankers be used?
- e. Check with dispatcher as to availability, overhead, men and machinery within time limits.

4. *Emergency action.*

- a. Opportunity for backfire before full attack ready?
- b. Readily available forces to carry out?

5. *Sector for first attack.*

- a. Which one or more sectors is most urgent?
 - (1) To avoid high hazards?
 - (2) To avoid steep slopes?
 - (3) To keep fire in one major area?
 - (4) To save high values?
 - (5) To tie in line and prevent flanking?
 - (6) Head or rear?
 - (7) To utilize available barrier?
 - (8) At most accessible point?
 - (9) To utilize available tanker or tractor?
 - (10) To insure safety of men?
 - (11) To discount probable shift of wind?
 - (12) To control sector which will not get into green, slow spread type?

6. *Camp location.*

- a. Needed?
- b. What is "center of gravity" for entire fire?
- c. What are safe locations?
- d. Can they be established or serviced by road, pack or airplane?

7. *Fire control organization.*

- a. How many sectors? Location and termini?
- b. Manpower, machinery and bosses each sector?
- c. Breakdown into crew units?
- d. Will line-holding and mop-up be handled by separate crews or by drop-off from original construction crew?
- e. Camp organization?
- f. Determine early as possible will next shift be needed?
- g. Understanding with dispatcher as to service of supply, replacements.
- h. Special communication set-up—radio net.
- i. Instructions to sector bosses on backfiring and timing of all operations.

C. *After control.*

1. *Mop-up.*

- a. Will separate crew and leaders be used as part of construction crew?
- b. Determine forces, machinery, tankers and leaders needed.
- c. Assign specific sectors to predetermined numbers of (b).

2. *Patrol.*

- a. Forces needed? Fresh men or part of crew already on line?
- b. Chance to use lookouts and radio?
- c. Chance to use horseback patrol?

3. *Reduction of forces.*

- a. Predicted weather conditions?
- b. Fire conditions elsewhere on Forest?
- c. Number needed for mop-up or patrol?
- d. Men from cooperating agencies who should be released?

D. *Scouting.* (May be needed during any period of planning; need for information determines need for scouting.)

- a. Set-up by agreement with dispatcher for continuous scouting service, securing as much information as possible for fire boss's use in actual operation of first attack.

DISPATCHING

Foreword

Dispatching is only in part a purely mechanical function, in which the dispatcher responds slavishly to orders sent by the fire boss. On many if not most fires independent judgment is or should be used by the dispatcher, both before and after the fire boss arrives at the fire. And in some cases the dispatcher is in position, because he possesses knowledge not available to the fire boss, to modify plans made on the ground.

The field for independent dispatcher action is defined principally by a large body of information readily available to him, and not often readily available to the fire boss on the ground.

The latter of course has the best basis for judgment insofar as direct visibility of the fire gives a basis. The latter, too, has advantages.

The more important kinds of facts available to the dispatcher alone are:

- a. Rate of spread zone map.
- b. Resistance to line construction.
- c. Tractor use map.
- d. Visibility map. Separate string maps.
- e. Aerial or panoramic photos.
- f. Relief models.
- g. Road, trail, firebreak, bridge capacity and water map.
- h. Current lookout reports.
- i. Current and predicted weather and danger elements.
- j. Location and availability of manpower and special equipment.
- k. Knowledge current forest-fire load.

Effective dispatching requires, of course, full systematic use of all such facts, as supplementary to those furnished by the fire boss. It requires systematic use of a routine in developing and putting into effect a plan of action for each fire—that is, use of a check list such as that in the following pages. And it requires clear recognition of the common types of situation in which independent dispatcher judgment should be exercised, such as those illustrated by the problems.

Forest

Fire

Date

DISPATCHER CHECK LIST OF INFORMATION AND ACTION

Initial		Initial Dispatch Action	Follow-Up Records and Calculations	Follow-Up Action on Initial Attack	Action when 2nd or Subsequent Shifts Required
Record	Information				
1	5	26-a	27	28	38
2	7	26-b	30-a	33	39
3	12	29	30-b	34	40
4		34	30-c	36	41
6	14	35	31	37	42
8	15	39	32-a	38	43
9	16	40	32-b	39	44
10	17		32-c	40	45
11	18			41	46
13	19			42	47
	20			43	48
	21			44	49
	22			45	50
	23			47	51
	24			49	52
				50	
				51	
				52	

- Numbers in columns refer to numbered items on Dispatcher Job List.
- Information received will be recorded promptly and fully on paper record (log, fire report, other forms).
- Place check mark opposite each number or cancel number when job has been considered or done.
- Use separate dispatcher check list for each fire to insure complete action on each fire.

DISPATCHER ACTION PLAN

<i>Item</i>	<i>Source of Information</i>	<i>Check From</i>
1. Time of report	Dispatcher's clock	
2. Time of origin (known or estimated)	Reporting agency	
3. Time of discovery	" "	
4. Person and station reporting	" "	
5. How can reporter be reached later?	" "	Dispatcher's log
6. Reported location of fire (natural features)	" "	Dispatcher map
7. Blind or seen area	" "	Seen area map
8. Azimuth and vertical reading	" "	Dispatcher map and panoramic photos
9. Map location	" "	Dispatcher map
10. Verification of existence of a fire	Other lookouts, residents, ranchers, etc.	Other lookouts and seen area map
11. Approximate size, estimated length, width and area	Reporting agency	
12. Direction fire traveling	" "	
13. Smoke, color, drift, volume	" "	Other lookouts
14. Apparent rate of spread to date	" "	Rate of spread map and tables
15. Estimated time period fire has been burning	Reporting agency ; record of elapsed time	Topographic, relief and hazard maps ; aerial and panoramic photos and relief model
16. Cover type at and ahead of fire	Reporting agency	Maps of cover type, inflammability or rate of spread, aerial and panoramic photos, hazard map

DISPATCHER ACTION PLAN—Cont'd.

<i>Item</i>	<i>Source of Information</i>	<i>Check From</i>
17. Character of fire, behavior ; crowning, spotting, running. etc.	Reporting agency	
18. Wind direction and velocity (current at fire) (predicted)	From smoke drift and general fire weather forecasts	Fire danger rating records. Special observations
19. Fuel moisture (current at fire) (predicted)	General fire weather fore- cast	Fire danger rating records. Special observations
20. Humidity (current at fire) (predicted)	General fire weather fore- cast	Fire danger rating records. Special observations
21. Visible barriers	Reporting agency	Barrier map, aerial and panoramic photos
22. Quickest and best route to fire	" "	Transportation map, dis- patcher map. Others fa- miliar with vicinity
23. Topography—including position of fire on slope	Reporting agency and map location	Topographic relief and haz- ard maps, aerial and pan- oramic photos and relief model
24. (a) How many men working on fire? (b) How long have they been working on fire?	Knowledge of location and use	Fire boss, later " " "
25. Probable cause of fire. Whether man caused or lightning		

DISPATCHER ACTION PLAN—Cont'd.

<i>Item</i>	<i>Check From</i>	<i>Source of Information</i>
26. (a) Send nearest guard, crew or cooperator by quickest determined route (b) Send nearest tank truck or machinery		
27. Keep posted on fire progress	All lookout reports—from fire	
28. Notify District Ranger		
29. Fill vacated positions with prearranged personnel	Organization charts	
30. Calculate size of job when initial attack man or crew arrives, taking into account the time of day and year (a) Hourly rate perimeter increase by types (b) Size and perimeter of fire at that time (c) Amount of work to be done by initial attack crew, making deductions for all barriers fire will not cross	Rate of spread map and tables. Evaluation of times	Computing from 27-a and b and resistance to line construction maps and tables
31. Calculate production expected of initial attack crew, including use of tankers or machinery initially dispatched		Production tables
32. If initial attack force not adequate on basis 27 and 28 determine size of job beyond power of initial attack force		

DISPATCHER ACTION PLAN—*Cont'd.*

<i>Item</i>	<i>Source of Information</i>	<i>Check From</i>
(a) Compute expected chains of line to be built at time reinforcements can arrive at fire, taking credit for initial attack crew's production		Rate of spread tables and map. Topography, barriers, cover, weather, rate of line construction map and tables. Transportation (travel time)
(b) Determine what portion of 29-a can be done by machinery if this can be made available		Tractor use map and tractor production tables, aerial and panoramic photos
(c) Determine man hours for lines that must be built by hand		Rate of production tables for types involved
33. Dispatch sufficient men, line overhead, tools, including lights, equipment, machinery and tankers to arrive at fire by designated routes within time limits to do the jobs required with reasonable margin of safety		Organization charts, transportation map, bridge map
34. Establish emergency patrol in incendiary area		Emergency fire plan
35. Lunches provided for initial crew and follow-up		Fire plan
36. Pack stock provided if needed		" "
37. Saddle stock for overhead ordered, sent		" "
38. Fire camp equipment sent		
39. Supplies ordered and sent (through Army if Army is to mess) including forage for stock		Army C.C.C.

DISPATCHER ACTION PLAN—Cont'd.

<i>Item</i>	<i>Source of Information</i>	<i>Check From</i>
40. Bedding sent		
41. Fire camp overhead selected and sent (incl. time-keepers) and their relief if necessary		Fire plan
42. Supervisor notified		
43. Specialized overhead ordered Fire boss, staff men, scouts, radio, telephone, tractor operators and mechanics, portable pumper operators, others as needed or requested		Fire plan
44. Evaluate need for reconnaissance or cargo airplane service, secure if needed		Emergency fire plan, Forest and R.O.
45. Notify Army C.C.C. District Headquarters if major campaign		
46. Notify adjacent Forests and cooperators of possible call		
47. Place other crews and personnel on stand-by		
48. Check adequacy and anticipate needs for trucks and pickups, trailbuilders and large trucks, tank trucks, auxiliary and slip-on tanker units, flamethrowers, radios, portable pumps and hose, tools and bedding, lights, camp equipment		Fire plan and equipment inventory records
49. Call Fire Weather Mobile Unit		Fire plan
50. Request special fire weather forecast ..	U. S. Weather Bureau	
51. Prepare and send fire telegraphic report to Regional Office if fire over 500 acres or cost more than \$500	Fire boss reports	
52. Arrange for and provide relief dispatcher		Fire plan

DISPATCHER ACTION
BEFORE FIRE BOSS ARRIVES AT FIRE
NORMAL RATE OF SPREAD IS BEING EXCEEDED

Problem 1

Conditions

Fire start 12:30 P.M.; discovery 12:50 P.M.; crew of 20 men dispatched 12:55 P.M. Should arrive 1:30 P.M.

Developing Basis for Follow-Up Action

1. After dispatching crew, dispatcher checks with two lookouts who can see fire. It is measured by them through binocular mil-scale as 8 ch. long at 1:00 P.M. This means a perimeter of about 20 ch. or a rate of spread of 40 ch. per hour.
2. Dispatcher checks on rate of spread zone map. Fire is in zone 1, and average for free-burning fires in zone 1 for the Forest is 20 ch. per hour.
3. Dispatcher checks on resistance to line construction map and finds that at and ahead of fire type is pine needles with scattered brush and reproduction and figures that 20 men can build about 28 ch. of line in one hour.
4. Long, continuous slope ahead of fire. No barriers or lines ready for backfiring. No chance to get and use special equipment.

Dispatcher's Conclusions

1. Fire will have 40 ch. perimeter when crew arrives.
2. Crew can build and hold at least 25 ch. per hour, working from rear up flanks.
3. If fire were spreading at normal rate of 20 ch. per hour crew could probably catch up with it.
4. At actual abnormally fast rate of spread shown by lookout reports, fire will make new perimeter approximately twice as fast as crew can build and hold line. Crew's output will be reduced due to fatigue after first hour while holding line will also cut down production forces.

Dispatcher Action

At 1:10 P.M. after this check-up, dispatcher sends fresh 20-man crew which should arrive not later than 2:00 P.M.

DISPATCHER ACTION BEFORE FIRE BOSS ARRIVES AT FIRE

SPECIAL HAZARDS AHEAD OF FIRE

Problem 2

Conditions

Fire reported to dispatcher at 1:00 P.M. Estimated to be 5 ac. in size in open manzanita brush type. Fire increasing at rate of 20 ch. perimeter per hour with estimated perimeter at this time of 30 ch. Will take $\frac{1}{2}$ hour for crew to reach fire. Crew of 36 men dispatched to fire immediately. After men dispatched rancher who reported fire calls and says fire is in next drainage north of where he previously reported it.

Developing Basis for Follow-Up Action

1. Rate of spread and rate of line construction and holding records indicate that the 36-man crew should complete fire line around fire in this type in about 2 hours (1:30 P.M.-3:30 P.M.). (Rate of production 2.6 ch. of line per man per hour with 4 men out for holding each 10 ch. of line.)
2. Dispatcher's special hazard map indicates a heavy stand of snags is located 16 ch. north of the north end of the revised location of fire (1:00 P.M.).
3. Rate of spread indicates this hazard will be reached by free-running fire in 1 hour (2:00 P.M.).

Dispatcher's Conclusions

1. Dispatcher knows fire boss will see smoke and reach fire. Realizes fire boss may not be familiar with location of snag hazard and will not plan his attack to prevent fire reaching the stand of snags, in which case fire will reach snags and control will be greatly delayed.
2. Even if fire boss knows of snag hazard and plans his attack accordingly, he will not be equipped with sufficient falling equipment and will have to concentrate his men on fire lining snag area and preventing entry of the fire with resultant delay in line construction on other sides of the running fire.

Dispatcher Action

At 1:10 P.M., after check-up, dispatcher learns of the location of the special snag hazard and estimates the crew on the ground is not able to handle the additional job; he dispatches a crew and fallers with falling equipment to the fire. This crew will concentrate on preventing the fire from reaching the special hazard snag area. Size of this crew will be based on length of line to be built, and the time available before fire will reach planned fire line.

DISPATCHER ACTION
BEFORE FIRE BOSS ARRIVES AT FIRE
BARRIERS ARE AHEAD OF FIRE

Problem 3

Conditions

1. Fire discovered 1:59 P.M. by lookout and reported at 2:00 P.M. Size $\frac{1}{8}$ ac.
2. Lookout reports fire located 50 ch. below top of ridge in head of small basin; total area of basin ahead of fire 165 ac.; total perimeter of basin 220 ch.
3. Initial action crew of 5 men dispatched 2:02 P.M. who are expected to arrive on fire by 3:00 P.M.

Developed Basis for Follow-Up Action

1. Fire spreading up slope—normal rate of spread (Lookout report).
2. Topography—moderate slopes with well-defined ridge ahead of fire, numerous small drainages in basin, also side ridges.
3. Fire season in full swing—normal fire weather (fire danger rating).
4. Fire in Zone 1 area—type, brush and scattered ponderosa pine timber—medium to dense.
5. Road traverses basin, passing 2 ch. above point of origin.
6. Two hydraulic diggings in basin near lower flanks of fire and side ridges as well as main ridge barren or semi-barren over major portion of linear length. Tailings from diggings create semi-barrier conditions in draws below diggings.
Data on type, details of location, topography, roads, barriers, from lookout, zone map, aerial and panoramic photos, transportation map, type map, and personal knowledge of country.

Dispatcher Conclusions

1. The dispatcher, on the basis of subsequent lookout reports, figures that the fire will be 40 ac. upon arrival of the control attacking force, and that its forward spread will be about 25 ch. This spread will in all probability necessitate sacrificing the small basin before control can be effected.
2. He concludes that initial attacking force will not be able to effect control.
3. The dispatcher cannot await the arrival of the fire boss to obtain direct information concerning the fire since approximately one hour of valuable time will be lost before his report is forthcoming.

4. Awaiting word from the fire boss will defeat the possibility of using these barriers as control lines. (See Figure 12, Problem 1, for picture of area, showing use in line location.)

Action

1. Dispatcher calculates the chains of line necessary to construct, utilizing the numerous barriers that are advantageously located for control purposes.
2. He finds that of the 220 ch. total perimeter of the basin, only $\frac{1}{4}$ of the perimeter requires line-construction effort.
3. He next calculates the manpower to construct this line and numbers needed for line holding, and immediately dispatches this number of men instructed to report to the fire boss on the fire.

DISPATCHER ACTION

BEFORE FIRE BOSS ARRIVES

NO APPARENT PRODUCTION AFTER HE SHOULD ARRIVE

Problem 4

Conditions

Fire starts 1:00 P.M., discovered 1:12 P.M., reported as $\frac{1}{2}$ ac.; 10-man crew dispatched 1:15 P.M., should arrive 1:45 P.M. Fire in rolling country.

Developing Basis for Follow-Up Action

1. After dispatching check shows:
 - a. Fire zone 1, open ponderosa pine type.
 - b. No change in type ahead.
 - c. Expected rate of line production 4 ch. per man hour.
 - d. Class 4 day, rate of spread expected approximately average for type, or 20 ch. per hour.
 - e. Expected perimeter on arrival 15 ch.
 - f. Crew should control without difficulty.
 - g. Only chance for trouble is if crew leader misses obscure side road that leads to fire. This road apparently leads away from fire. Crew leader warned to watch for right-hand turn-off and given diagram of road.
 - h. Dispatcher checks with lookout at 2:00 P.M. Report, no apparent control on fire.

Dispatcher Conclusions

1. Crew leader has missed road.
2. Will probably lose an hour.
3. Fire when he arrives will be dangerously large for his 10-man crew.

Action

Dispatch second 10-man crew, having them pick up reliable local rancher on way to fire to act as guide.

DISPATCHER ACTION BEFORE FIRE BOSS ARRIVES

INDEPENDENT DISPATCHER ACTION LACKING REPORTS FROM FIRE BOSS WHEN APPARENTLY SPREAD OF FIRE IS FLANKING LINE BEING BUILT

Problem 5

Conditions

- Fire starts 12:30 P.M.; 10-man crew with leader should reach fire 1:30 P.M. Crew went in by trail, which put them near head of fire $\frac{1}{3}$ way up uniform, moderately steep slope, ponderosa pine type, medium reproduction and brush. Fire reported by lookouts as 7 ch. long at 1:30 P.M.; this is about 20 ch. per hour or normal for free-burning fires in this type on the Forest.

Developing Basis for Follow-up Action

1. Dispatcher checks with lookouts at 1:45 P.M. Report is that line is being built starting at head of fire and going down both sides. Line apparently holding.
2. Dispatcher again checks, 1:55 P.M. Report that rear of fire has rolled to canyon bottom, has caught in flash type of grass and scattered brush, and up-canyon wind in open has swept it 5 ch. up canyon.

Dispatcher Conclusions

1. Fire boss not likely to see this change in fire because of smoke.
2. The new fire will sweep up canyon flank and flank entire line.
3. When this happens (about 2:15 P.M.-2:30 P.M.) fire boss will be compelled to use most of his men, starting at canyon on flank to prevent continued spread up canyon in stringer of flash fuels.
4. This will leave head of fire free to go on up the mountain.
5. Absence of word from fire boss means he thinks his strategy is working and that he doesn't need additional men.

Dispatcher Action

Sent 20-man crew in on same trail, to take either flank or head, depending on fire boss decision when they arrive.

DISPATCHER ACTION AFTER FIRE BOSS ARRIVES

SPOT FIRES PROBABLY INVISIBLE TO FIRE BOSS

Problem 6

Conditions

Fire reported to dispatcher at 2:00 P.M. Estimated to be 5 ac. in size, burning up a 20% slope, brush-covered and with down logs, at linear rate of 5 ch. per hour. Top of ridge estimated 15 ch. from upper end of fire. Crew of 16 men dispatched and expected to reach fire at 2:30 P.M. No direct word from fire.

Developing Basis for Follow-Up Action

Dispatcher instructs Lookout to watch carefully. At 5:00 P.M. receives call from Lookout (5 miles from fire) that two spot fires, about $\frac{1}{8}$ ac. each, have started on opposite slope of ridge from main or original fire. No word received from fire boss.

Dispatcher's Conclusion

Recognizes that suppression crew members probably all on fire lines of original fire and not near enough to ridge to see spot fires for some time.

Action

Dispatcher acts immediately to start new crew to handle both spot fires, recognizing (1) probable accuracy of Lookout's report on spot fires, (2) probable lack of opportunity for first crew to see spot fires even if it had men who might be spared for scouting that far ahead.

DISPATCHER ACTION AFTER FIRE BOSS ARRIVES

NO DIRECT REPORT, BUT OTHER FIRES SPREADING FASTER THAN NORMAL

Problem 7

Conditions

1. Fire reported by United Air Lines transport plane to be burning 1 mile below mouth of Janes Creek on Trout River. Area about 50 ac., spreading up slope; time of discovery 11:00 A.M. Head of fire $\frac{1}{4}$ way up slope, spreading about as fast as a fire they reported last month.
2. Inflammability zone map placed this fire in Zone 1.
3. Type map and aerial photographs show medium mixed brush type in this and adjacent drainages.

4. Aerial photographs and topographic maps show there is a well-defined ridge running parallel to the river, that the ground distance from the river to the top of this ridge is 1 mile, that there is a road along the river, and that there are several spur ridges that can be used for line location along the flanks of the fire.
5. Using the information gathered on the fire reported last month by the United Air Lines as a measuring stick, the dispatcher estimated the head of the fire would reach the ridge in about $4\frac{1}{2}$ hours, and that if the forward progress of the fire could be stopped at this point the side spread would not be rapid, and that the fire could be controlled with a perimeter of 4 miles if present weather conditions continue as indicated.
6. Whole slope invisible to Lookouts.
7. The dispatcher estimated that it would take 100 men to effect control of fire and 50 men to relieve these men during the night. 100 men under competent leadership were dispatched immediately. It was planned that they would have a line around the fire by 4:00 P.M.
8. The fire boss called in upon his arrival at the fire at 12:30 P.M. and stated the fire was $\frac{1}{2}$ the way up the slope, area 100 ac., burning quietly—will catch head of fire first—wind 4 mi. per hour up slope.

Developing Basis for Follow-Up Action

1. 2:00 P.M.—no word from fire boss since 12:30 P.M.
2. 2:15 P.M.—adjacent Ranger District dispatcher called in, stating that they are having trouble holding their fires—rate of spread increasing sharply due to increased velocity of wind. Wind now 15 mi. per hour up slope.
3. No chance for Lookout check on his fire.
4. Probably similar change on his fire.
5. The effect of the increase of wind velocity from 4 to 15 mi. per hour makes it necessary to recalculate the manpower needed to construct the additional line made necessary due to the increased velocity of the wind. The increased difficulty in holding must also be considered.
6. The dispatcher knows there is trouble ahead since the forces on the fire were based on the conditions prevailing at that time.

Action

Lacking information from the fire boss, the dispatcher recalculates the additional forces needed and immediately dispatches them to the fire with instructions to report to the fire boss or his representatives.

DISPATCHER ACTION

AFTER FIRE BOSS ARRIVES

FIRE BAD BUT WILL GET INTO EASIER AREA

Problem 8

Conditions

Fire start 11:00 A.M.; high Class 4 day; upper edge ponderosa pine type; first attack 5 men 10:45 A.M.; fire not caught; 25 men reinforcements arrive 1:15 P.M.; perimeter at 1:15 P.M. about 80 ch.; lookout reports fire being worked from rear up both flanks. No direct report from fire boss.

Developing Basis for Follow-Up Action

1. Lookout reports indicate fire making new perimeter as fast as crew is building and holding line. Advises sending more men.
2. Dispatcher has no word from fire boss.
3. Dispatcher finds that 10 ch. ahead fire will run out of Zone 1 and into Zone 2.
4. Rate of spread will decrease around $\frac{2}{3}$ from about 35 ch. of perimeter per hour, to some 12 ch. per hour.

Dispatcher Conclusions

1. With this change in spread, the crew of 35 men will catch up with the fire by about 5:00 P.M.
2. It is unnecessary to send more men.
3. The question of patrol and mop-up crews can wait word from the fire boss.

DISPATCHER ACTION

AFTER FIRE BOSS ARRIVES

MAJOR SHIFT OF WEATHER FOR WORSE PREDICTED

Problem 9

Conditions

Fire in heavy mixed brush; started 1:00 P.M. according to Lookout report; apparently controlled by 40-man crew at 5:00 P.M., partly by direct attack and at head by backfire; high Class 4 day. Fire apparently holding. No direct report from fire boss.

At 5:30 P.M. prediction of quick shift to Santa Ana (strong east or northeast) wind.

Dispatcher's Conclusions

1. Recent backfired area will be raw and hot in this type.
2. Santa Ana wind will create great danger of spotting from recent burn.

3. Men on fire will be too tired to be fully effective in meeting fresh threat and heavy line-holding job.

Action

Immediate dispatch of fresh men and leaders calculated to reach fire well ahead of probable shift in wind.

DISPATCHER ACTION AFTER FIRE BOSS ARRIVES BOSS UNABLE TO SEND OUT FOR HELP

Problem 10

Conditions

A crew of 2 men had been sent to a lightning fire 2 mi. from the road at 10:30 A.M. Fire was still smoking without noticeable abatement or increase at 5:00 P.M. Fire is estimated by Lookouts to be about 1/10 ac. in size. No report from fire.

Developing Basis for Follow-Up Action

1. Dispatcher from his type and topographic map data estimates men should have reached fire at 1:45 P.M.
2. He checks with the Lookouts, who still think the area of the fire is not more than 1/10 ac. with a perimeter of about 5 ch.
3. The type map indicates the fire is in a closed timber type and the fire line construction data indicate it should be controlled by two men easily in a little over one hour.
4. Allowing an extra hour for falling a possible snag, the smoke should have disappeared by 4:00 P.M.
5. No word has been received from the fire by 5:00 P.M.

Dispatcher's Conclusions

1. The dispatcher estimates that either the men have not been able to locate the fire, or having located it have found it to be a larger job than estimated and have been unable to control it, but have stayed with fire expecting help on Lookout progress reports.
2. He also knows that while the men took an emergency lunch they have no lights for night work.

Action

The dispatcher sends two more men, one of whom is thoroughly familiar with the country, to the fire with extra food and four flashlights.

DISPATCHER ACTION

REVISION OF FIRE BOSS'S ORDER BY DISPATCHER REPORT FROM FIRE BOSS GIVES PICTURE OF FIRE RADICALLY DIFFERENT FROM THAT DEVELOPED BY DISPATCHER

Problem 11

Conditions

Fire boss believes bad cover condition in which fire is now burning continues indefinitely; dispatcher knows they improve greatly a short distance ahead.

Fire started 2:00 P.M. in flash fuels (grass and scattered brush) in canyon; spread almost straight up hill; little wind; heavier brush for some 10 ch. higher up in canyon where fire started; reports from fire boss checked by Lookouts indicate fire is 20 ch. long at 3:00 P.M. when boss and 60 men arrive. Fire boss (new man in this area) wants 100 more men, two camps established and necessary overhead.

Developing Basis for Follow-Up Action

1. From rate of spread and resistance to line construction maps, dispatcher finds that 10 ch. ahead of estimated 3:00 P.M. head of fire, type changes from medium brush to ponderosa pine timber with scattered brush and reproduction.
2. Spread will drop from about 50 ch. per hour to not over 20 ch.
3. Total line to build as of 4:30 P.M., free-burning fire conditions:

a. Grass and light brush	45 ch. $\div$ 3.3 =	14	man-hours.
b. Medium brush	20 ch. $\div$ 1.2 =	17	" "
c. Timber	20 ch. $\div$ 1.4 =	14	" "
Totals	85 ch.	45	" "
4. Crew fresh, seasoned men, excellent fire fighters, good leaders.
5. Present crew should be sufficient to control fire soon after 4:00 P.M. with enough slack for line-holding and contingencies.
6. Fire boss appraisal of needs based on assumption that conditions for a long distance ahead are same as those in which fire now burning. A natural error, since he has had no chance to learn details of the country.

Dispatcher Action

Called fire boss back, explained conditions and his conclusions, and readily got fire boss's agreement to stick with initial crew and that no heavy follow-up required.

DISPATCHER ACTION
REVISION OF FIRE BOSS'S ORDER BY DISPATCHER
OPTIMISTIC REPORTS, BUT WORSE CONDITIONS AHEAD
Problem 12

Condition

Suppression crew of 8 men, in charge of guard serving his first season in fire work, is sent to 3-ac. fire at 1:30 P.M. Fire located in medium cutover type with perimeter of 30 ch. The fire boss (guard) radios the dispatcher at 3:15 P.M. He reports his crew reached fire at 2:00 P.M. and at 3:00 P.M. has a good line around $\frac{1}{3}$ of the fire perimeter. He assures dispatcher that entire fire will be controlled in from 2 to 2½ hours despite an increase in wind from 10 to 15 mi. per hour from 2:30 to 3:00 P.M.

Developing Basis for Follow-Up Action

Dispatcher phones for latest weather prediction and learns wind is expected to increase its velocity until it reaches 30 to 35 mi. per hour at 4:00 P.M. with continued very low humidity and 5% fuel moisture.

Conclusion

Dispatcher realizes that guard is unduly optimistic, even on control with a 15-mi. wind and that with a 30 to 35 mi. wind at 4:00 P.M. the control job cannot possibly be completed by 5:00 P.M. to 6:00 P.M. He has not enough men to control it under existing spread conditions. (Wind increase of 20 mi. per hour will increase rate of perimeter spread around 400%.)

Action

Dispatcher talks to fire boss again by radio. Latter still feels sure fire will be controlled before darkness despite increased wind and arguments of dispatcher. Dispatcher realizes the guard (fire boss) has never experienced a 30-mi. wind on a brush fire and phones Supervisor, who checks his judgment of action needed. The dispatcher thereupon dispatches the needed reinforcements to assure control of the fire that night.

DISPATCHER ACTION

REVISION OF FIRE BOSS'S ORDER BY DISPATCHER

ESTIMATE OF FIRE'S SIZE TOO HIGH

Problem 13

Conditions

1. Dispatcher receives a request for additional men from the fire boss, who is known to be competent in every respect except the factor of judging the size and perimeter of a fire.
2. Fire season in full swing with normal fire weather. Lookout who has proved his accuracy in estimating the area of fires of moderate size has direct visibility in the area. Fire 4 mi. distant, time 2:00 P.M.
3. Fire boss (young guard) calls the dispatcher and states the fire is 100 ac., that it will be necessary to construct 170 ch. of fire line, and that this will take 75 more men.

Developing Basis for Follow-Up Action

Dispatcher calls the Lookout and learns the fire is not over 20 ac. He also learns that the fire is almost circular in shape. Using the conversion table on page 181 of the General Section of the Fire Control Handbook as a guide, he determines the perimeter of the fire is around 80 ch. or about $\frac{1}{2}$ the perimeter given by the fire boss.

Action

Dispatcher calls the fire boss and asks him to check his area again to make sure he has not made a mistake in his calculations. Fire boss states he is sure he is right. Dispatcher sends men required for 20-ac. fire with small allowance for safety. He also sends in a more experienced man to advise and assist the fire boss in his control work, especially that of estimating the perimeter of the fire.

DISPATCHER ACTION
REVISION OF FIRE BOSS'S ORDER BY DISPATCHER
UNNECESSARY FORCES FOR JOB ORDERED

Problem 14

Conditions

A crew of 40 men is sent to a fire. The fire is located in level topography and in a heavy mixed-brush type, Zone 2. Fuel moisture is 8%, relative humidity 50%, and wind 10 mi. per hour without expectation of change. At 2:00 P.M. the fire boss radios the dispatcher, tells him the fire is about 8 ac. with a perimeter of 40 ch. and states he has just started fire-line construction work, but in order to complete the fire-line construction and holding job prior to nightfall (about 8:00 P.M.) he wishes 50 more men and 2 RD-7 trailbuilders sent out to reach the fire by 3:00 P.M. He is not able to give his basis for the number of men or tractors requested other than that he felt his present crew could not handle the job and the 2 tractors would be mighty useful in the heavy brush.

Dispatcher's Conclusion

The dispatcher estimates that the maximum perimeter of the fire will be not over 80 ch. (Zone 2, rate of spread 10 ch. per hour) if it burns unchecked until 6:00 P.M. Crew working will naturally reduce rate new perimeter is being produced. The crew of 40 men will build and hold some 17 ch. of line in the first hour, 10 ch. the second, and from then on will have difficulty with the decrease in strength developed for holding and patrol and fatigue in building line as fast as fire is spreading. The available line-construction data indicate tractor can construct 10 ch. of line in the heavy mixed-brush type in 1 hour. This will give the additional line-construction power to catch up with the fire by nightfall. A backfire and holding crew of 16 men was sent in with the tractor to make its work effective.

Action

The dispatcher phones the fire boss and informs him of his estimates and the data used. The dispatcher suggests sending 16 more men and 1 RD-7 trailbuilder. The fire boss agrees to the revised estimates of equipment and manpower. The fire is controlled and held, with only patrol work needed, at 7:30 P.M.

POINTS TO CONSIDER IN DISPATCHING

1. Careful current check should be made by dispatchers from Lookout reports and any other reliable sources of reports on changes in condition of fires to which men have been dispatched that indicate they are not acting the way their plan of control had been figured.

2. When, after a reasonable time has elapsed, reports from competent sources indicate crew dispatched to a fire has not made the headway toward controlling it that seems reasonable, follow-up help should be sent in to be sure positive and effective control action is being taken.

3. When dispatcher has definite reliable report that disaster has overtaken his suppression forces, he should send in help without waiting for call from the fire.

4. When excessive trouble is being experienced in controlling fires in adjacent areas indicating that abnormally difficult conditions exist, the dispatcher should back up his crews on all fires from which he cannot secure positive reports that such help is not required.

5. Dispatcher should take action on his own initiative to strengthen attack forces when immediately impending critical weather changes are forecast without formal orders from the fire boss.

6. Dispatcher should be sure fire boss has been in the possession and has considered fully all of the essential factors not only in fire behavior but also changes in cover types, etc., in his plans. If he feels certain the boss has overlooked some essential factor or has not been cognizant of all of these, they should be brought to the boss's attention before major changes in existing set-ups are made.

7. Where fire boss is known to lack experience, dispatcher should be particularly careful to check on his actions and to follow up to be sure adequate but not excessive action is being taken to fit the needs.